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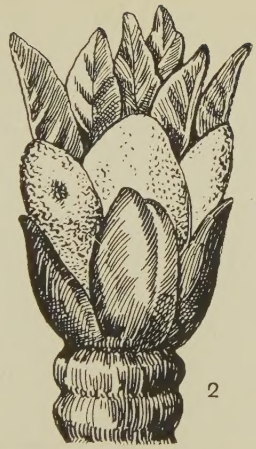
SUCCESSFUL SPRAYING



Spraying Stages of Fruit.

1. *Dormant Stage.*—When the buds commence to swell. 2. *Late Dormant Stage.*—When bud scales are relaxing. 3. *Pink Stage.*—When flower petals are conspicuous but blossom still unopened. 4. *Blossoming Stage.*—Flowers opened with stamens and other parts fully exposed. 5. *Calyx Stage.*—The "blossom" has just fallen but the calyx remains fully open.

SUCCESSFUL SPRAYING

AND HOW TO ACHIEVE IT

A HANDBOOK FOR GROWERS
NURSERYMEN, HORTICULTURISTS
GARDENERS AND AMATEURS

BY

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'INSECT PESTS AND FUNGUS DISEASES OF FRUIT AND HOPS'

ILLUSTRATED WITH 82 ORIGINAL PHOTOGRAPHS
AND DIAGRAMS

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PREFACE

THE object of this book is to deal with the subject of Spraying as a business proposition, for the information and guidance of the practical grower, and for all those who raise crops which are subject to attacks of insects or fungi.

Under present day conditions, every business man finds himself faced with ever growing competition, which makes it increasingly necessary to eliminate all old-fashioned and inefficient rule-of-thumb methods, if he is to maintain his position and run his business at a reasonable profit.

Probably none of our British industries has had to pass through a more trying period, or is faced with a more difficult future outlook than that of agriculture in all its various branches, including that relating to the growing of fruit and similar crops. It becomes therefore of the highest importance, if success is to be attained, to ensure the efficiency of all the different operations concerned.

Without question the most serious factor with which the fruit grower has to contend is the constantly recurring risk of the destruction of his crop by insect and fungus enemies, and it is obvious that the consideration of the efficiency of the remedies to be employed to combat successfully such attacks is of the greatest possible moment.

The present book is not concerned mainly with the purely scientific aspect of the subject, and does not pretend to deal exhaustively with all the pests with which the grower has to contend. It endeavours to explain, in simple language, the underlying principles which make for

efficiency, and at the same time an endeavour is made to embody practical details of up-to-date practice in spraying and also to describe all those commonly occurring pests which are responsible for financial losses to the grower, either by stunting or disfiguring the fruit or by seriously reducing the output.

The question of safe and effective remedies and their efficient application is considered in detail, as is the important factor of the water supply, and the successful utilisation of hard waters in spraying. A chapter is devoted to the new method of dry spraying, in which the insecticide is held in an absorbent powder instead of being dissolved in water.

The chemical aspects of the subject, a working knowledge of which is becoming increasingly necessary to the successful grower, are dealt with in as simple and direct a manner as possible.

The photographic illustrations have, in the main, been specially prepared, but the author is indebted to the Cambridge University Press for permission to use photographs which have already been reproduced in his larger work on *Insect Pests and Fungus Diseases*. For further details of the pests described in this book, and for fuller information, the reader is referred to the above-mentioned work.

PERCIVAL J. FRYER

RAVENSCAR,
TONBRIDGE,
September 1923

CONTENTS

PAGE

CHAPTER I

INTRODUCTION 17

The importance of spraying—the house garden—the large plantation—efficient spraying.

CHAPTER II

HOW TO ENSURE EFFICIENT SPRAYING 20

Recognising the attack—knowing the right time to apply the remedy—selecting the right type of remedy—purchasing the most efficient grade of material—applying the remedy in the correct form—applying the remedy in the right manner—ensuring freedom from damage—conducting one's own research.

CHAPTER III

SPRAYING WITH AN OBJECT 28

Avoiding injuries to the fruit—injuries caused by physical agencies—friction and action of wind—hailstone injury—sunburn—frost injury—injuries caused by insects and fungi—apple scab disease—aphis—capsid bug—sawfly—codling moth caterpillar—brown rot disease.

CHAPTER IV

TACTICS OF WARFARE AGAINST INSECT ENEMIES . . 35

Importance of early spraying—newly hatched insects—advantages of autumn spraying for aphis and psylla.

CHAPTER V

DESTROYING THE SAP-FEEDERS 42

A practical classification of insects—the sucking pests—aphides—psylla—capsid bugs—hoppers—scale insects—mites and spiders—necessity of a contact spray—sucking insects must be thoroughly wetted with spray fluid—effect of soap and spreaders.

PAGE

CHAPTER VI

CONTROLLING THE LEAF-EATERS 52

Poison sprays acting through digestive system necessary—suitable poisons—the arsenates—importance of fine division—method of spraying—Derris—precautions when using poison sprays.

CHAPTER VII

HIDDEN ENEMIES 62

Apple blossom weevil—control of the pest—destroying capped blossoms—liming and lime sulphur applications—a successful treatment—apple sawfly—pear midge.

CHAPTER VIII

THE QUESTION OF THE WATER SUPPLY 70

Hardness of water—rain water—uplands surface water—surface water from cultivated lands—shallow well water—deep well water—sea and brackish waters—practical testing—explanation of illustrations.

CHAPTER IX

THE CHEMISTRY OF SPRAYING 80

Elements and compounds—chemical combination—fatty acids and soaps—arsenates and arsenites—sulphur and its compounds—derris and nicotine.

CHAPTER X

SUBTERRANEAN PESTS 89

Powder and liquid poisons—the eelworm—other ground pests—woolly aphis—use of carbon bisulphide—powder insecticides—a pest of the vine—calcium carbide.

CHAPTER XI

FUNGUS DISEASES 99

Principles of treatment—contact sprays—fungicides—copper compounds—apple scab—apple canker—apple mildew—brown rot—apple blossom wilt—cherry leaf curl—cherry leaf scorch—cherry scab—American gooseberry mildew—peach leaf curl—pear scab—silver leaf.

PAGE

CHAPTER XII

INSECTICIDES AND FUNGICIDES 109

1. Insecticides for sucking insects.

Derris—action on insects—action on mammals—methods of use—strength of spray.

Nicotine—use—commercial varieties—action on insects—action on mammals—strength of spray.

Quassia—use—action on insects—method of spraying.

Paraffin oil—use—as emulsions—method of spraying.

Lime-sulphur—general description—method of use—strength of spray.

Caustic soda—use—strength of spray.

Lime—use—strength of spray.

2. Insecticides for chewing insects.

Derris—a stomach poison and contact poison combined—strength of spray.

Arsenate of lead — use — properties — precautions in use — strength of spray—notes.

Pyrethrum—properties—method of use.

3. Spreaders.

Soap—calcium caseinate.

4. Fungicides.

Lime-sulphur—Bordeaux mixture—method of preparation—use—Burgundy mixture.

CHAPTER XIII

UP-TO-DATE SPRAYING 120

Fundamental principles—spraying machines—spray gun—types of machines—combined sprays—dry spraying.

CHAPTER XIV

FUMIGATION 131

General principles—cyanide—method of cyaniding—tetrachlorethane—tobacco and nicotine preparations.

CHAPTER XV

DESCRIPTION OF INSECT AND FUNGUS PESTS . . . 133

A. **Pests of the Apple.**

(*a*) *Insect Pests.*

Blue apple aphis—green apple aphis—woolly aphis—apple sucker (psylla)—capsid bug—mussel scale insect—winter

PAGE

moth caterpillar—March moth—mottled umber moth—codling moth caterpillar—lackey moth—tortrix and bud moth—apple blossom weevil—apple sawfly.

(*b*) *Fungus Diseases.*

Apple scab—brown rot—apple mildew—apple canker—apple blossom wilt.

B. **Pests of the Plum.**

Leaf curling plum aphis—mealy plum aphis—winter moth—March moth—mottled umber moth—plum fruit sawfly—plum rot—silver leaf—plum wither tip.

C. **Pests of the Pear.**

Black aphis—social sawfly—slug worm—pear midge—pear leaf blister mite—pear scab—pear leaf spot.

D. **Pests of the Peach.**

Insect pests—peach leaf curl.

E. **Pests of the Cherry.**

Insect pests—cherry blossom wilt—cherry leaf curl—cherry leaf scorch—cherry scab.

F. **Pests of Currant and Gooseberry.**

Gooseberry and currant sawfly—currant clearwing—currant gall mite (big bud)—gooseberry red spider—American gooseberry mildew—die-back of gooseberry—currant leaf spot.

G. **Pests of Raspberry, Strawberry and Blackberry.**

The raspberry moth—raspberry weevil—raspberry beetle—raspberry aphis—strawberry aphis—raspberry rust—strawberry leaf-spot—strawberry mildew.

INDEX 153

LIST OF ILLUSTRATIONS

Spraying stages of fruit . . . . . *Frontispiece*

FIG. PAGE

1. Well formed, healthy apple 29
2. Skin of apple marked by contact with twig, etc. . . 29
3. Corky roughening of skin caused by friction . . 29
4. Hailstone injury 29
5. Fungus rot resultant on puncturing skin . . . 29
6. Injury due to sunburn 29
7. Injury due to frost 29
8. Disfigurement caused by caterpillars 30
9. "Maggotty" apple due to codling attack . . . 30
10. Injuries caused by sawfly maggot 30
11. Distortion and stunting resultant on aphis attack . 30
12. Scars, distortion and under-development due to capsid-bug attack 30
13. Fruit attacked by the brown-rot fungus . . . 30
14. Blotches caused by the apple-scab disease . . . 30
15. A typical example of apple-scab (black-spot) disease on apple 30
16. Newly hatched aphis on twig of apple 37
17. Newly hatched aphis on young leaves 37
18. Newly hatched aphis on young leaf (magnified) . . 37
19. Aphides laying eggs on apple leaves in autumn . . 39
20. Twig in late autumn, showing result of activities of egg-laying aphides 40
21. Magnified view of aphides and eggs 40
22. Diagram of life-history of blue apple aphis . . 41

FIG. PAGE

23. Typical "sap-feeders." 1. Aphis. 2. Psylla. 3. Capsid-bug. 4. Leaf-hopper. 5. Scale insect. 6. Red spider 43

24. Typical aphides, showing "beak" or "sucking tube" . 44

25. Plum leaf covered with "mealy" aphides . . . 45

26. Mealy plum aphides (magnified) showing waxy "meal" 46

27. Typical aphides enlarged, showing water-resisting coating of bodies 46

28. Magnified view of leaf sprayed with plain water . 47

29. Enlarged view of leaf surface sprayed with insufficient soap to "kill the hardness" 48

30. Leaf surface enlarged, showing the perfect wetting obtained with soft soap in sufficient quantity . . 48

31. Aphides sprayed with a wash containing insufficient soap to kill the hardness. . . . does not flow over or cover them. (highly magnified) 49

32. Aphides sprayed with a wash containing sufficient soap to destroy the mineral salts. . . . an efficient result. (magnified) 50

33. Rates of settlement of samples of arsenate of lead—after four seconds 55

34. As fig. 33, after lapse of one minute 55

35. As fig. 33, after eight minutes' settlement . . . 56

36. As fig. 33, after duration of twenty-four hours . . 56

37. Brand (a) arsenate of lead seen under the microscope showing coarse aggregation of particles . . . 57

38. Brand (b) arsenate of lead, showing finer aggregation of particles 57

39. Brand (c) arsenate of lead, very highly magnified, showing the uniformly fine particles 58

40. Corpuscles of human blood magnified to same extent as fig. 39 for comparison 58

41. Showing effect of a too heavy spraying of arsenate of lead, causing the leaves to drip, etc. 59

42. Showing the result of a coarse spray with coarse materials, etc. 59

43. Efficient spraying with arsenate of lead, a fine spray with fine materials, etc. 60

FIG. PAGE

44. Apple blossom weevil damage showing capped blossom . 64

45. "Cap" of blossom removed to show pupa of weevil within 65

46. Apple sawfly, (a) External view of infested fruitlet, (b) the same, cut open to show maggot and injury . 67

47. Pear midge, (a) and (b) healthy fruitlets. (c) Infested pear fruitlet, etc. (d) External view of same . . 68

48. A simple method of testing the hardness of water or ascertaining the amount of a wash to employ . . 74

49. The water with hardness partially "killed." The turbidity, etc. 75

50. The hardness of the water just "killed," etc. . . 76

51. As in fig. 50, but with slight addition, etc. . . . 76

52. False head of lather produced when much magnesium salts are present in the water, etc. 77

53. Illustration of chemical combination. 23 parts by weight of the metal sodium, etc. 82

54. 100 ozs. of the chemical compound hard soap (E) produced by dissolving 9 ozs. of caustic soda, etc. . . . 83

55. The production of 100 ozs. of soft soap (E) by the chemical action of $8\frac{1}{2}$ ozs. of caustic potash, etc. . . . 84

56. The splitting of oil into its component parts, viz. fatty acids and glycerine, before combination with caustic potash, etc. 85

57. Woolly aphis attack on root of apple tree . . . 91

58. Woolly aphis, showing masses of wool (magnified) . 92

59. Young apple tree attacked by woolly aphis . . 93

60. View of injector 94

61. Operating the injector—note liquid issuing from side of nozzle 95

62. Making the injections in positions indicated by pegs . 96

63. Brown rot of apples, showing diseased and healthy apples. The latter specimen is becoming infected at the point of contact between the two . . 101

FIG. PAGE

64. Bad example of apple canker. Cankered branch . 103

65. Apples badly affected with apple scab and black spot disease 104

66. Silver leaf disease on a victoria plum, showing healthy and silvered leaves 105

67. Fruiting stage of the silver leaf disease on a dead branch of victoria plum tree 106

68. Spraying fruit with a medium-power petrol machine . 121

69. Spray gun in operation, adjustment for fine misty spray 122

70. Spray gun in operation. Coarse powerful spray of great length, reaching to the tops of trees . . 122

71. Spraying high fruit trees, by use of long lance and a platform spraying machine 123

72. Photograph of an efficient misty spray . . . 124

73. Syringe sprayer suitable for amateur use only . . 125

74. Knapsack sprayer. This is strapped on the back and is operated by, etc. 125

75. Automatic compressed air sprayer. An alternative to the knapsack type. Capacity about the same . . 125

76. Wheelbarrow sprayer. Suitable for small plantations. Capacity 12-50 gallons 126

77. A simple and inexpensive form of petrol power sprayer. $1\frac{1}{2}$ h.p. engine 126

78. A useful machine for medium-sized plantations . . 127

79. Type of 3 h.p. sprayer with 2-throw high pressure ram pumps and 100-gallon steel tank. A useful type for all needs 127

80. A powdering machine for use on fruit trees . . 129

81. Tree with band of sticky composition to catch the wingless female of the winter and other moths . . 137

CHAPTER I

INTRODUCTION

In an ideal world, the necessity for protecting crops of all kinds against attacks of various enemies would doubtless not exist. In such "Edenic" conditions spraying would be superfluous. In the world as we know it, however, the fruit of the earth has needed unremitting toil and care to bring it to perfection, and the most important of all the operations in connection with the growing of fruit and many other crops is unquestionably the one which forms the subject of this book—spraying. This must be acknowledged when it is considered that all conceivable care may be given to fruit trees and other plants, but without efficient spraying to control the ravages of insects and diseases, the crop may easily prove a complete failure.

The Importance of Spraying.

Although practically all successful growers the world over recognise this, and in fact owe their success mainly to its recognition, it is nevertheless nothing short of astounding to find how large a number of the smaller growers still fail to see the fundamental importance of spraying.

Spraying is really insurance. It protects the crop. Yet many growers who would not dream of taking the risk of damage by fire to their buildings, take immensely greater risks each year with pests and diseases of all kinds on their fruit.

In addition to ensuring profits, there is the æsthetic side to the question. A healthy, well sprayed orchard, bearing clean, shapely fruit is a continual delight to the eye, and the pleasure it gives is not confined to the commercial grower, but applies equally to the man who grows but a single fruit tree in his back garden.

The House Garden.

A friend of the author's had two apple trees at the back of his house, which each year gave a very fine show of blossom, but proved completely delusory as regards fruit. A few scabby or wormy apples, minute in size and quite worthless, were occasionally obtained, but fruit of any sort was a rare event. The practical extent of the usefulness of the trees was to help to support the clothes on washing day. A year or two ago these trees were sprayed, and each season since has seen both trees bearing a magnificent crop of healthy, clean apples, reddening under the summer sun, a delight to all beholders, and the pride and profit of their owner. How many thousands of similar instances are there where trees are, metaphorically speaking, crying out for the same treatment ?

The Large Plantation.

It is in the case of large orchards and plantations, however, that the need for systematic spraying is greatest. All over the fruit-growing districts of the world—and the same applies largely to other crops—huge profits are being made in systematically sprayed orchards. According to statistics in America, over eight times the profit per acre is being made on fruit land than where grain crops only are raised. What would be the record if all this fruit were efficiently sprayed ? Of course there is "spraying and spraying." Inefficient spraying is a useless expense.

Efficient Spraying.

Early in the present year a most interesting paper was read before the Federation of British Growers by a gentleman [1] who has made a life study of the question of efficiency in business, and the application of scientific methods to everyday operations. The title of his lecture was "How Efficiency Methods could be Applied to Growing Crops and to Agriculture generally." He pointed out that the growing of fruit and other crops was closely related to an

[1] Mr Herbert Casson.

ordinary business ; in fact, that " growing was manufacturing," and that the successful grower could no more do with guesswork, makeshift, and rule-of-thumb methods than could any modern up-to-date business house. There had to be definite scientific knowledge of each process, whether of manufacturing or growing, and a careful and painstaking application of methods which experience and research had proved sound and effective. It must be admitted that these remarks were very opportune and greatly to the point. If any grower of crops wishes to prosper in the future, or even hold his own, the old, easy-going conservatism, the prejudice to new and better ideas, the haphazard, unscientific, " leave - it - to - the - foreman " methods must be replaced by an open-minded and whole-hearted application of scientific principles to every stage of the business. If, therefore, the foregoing arguments are correct, they are of special importance in connection with the operation of spraying, since the entire crop, *i.e.* the profits of the business, are at stake. Nor is that all, for neglect of this operation will often result in permanent injury to the health and cropping powers of the tree.

Further, spraying is not an operation which can be evaluated on arithmetical principles—it is not a sum in proportion ! If I use half the spraying liquid necessary to wet the leaves, the result is not half as good, but probably an entire waste of labour and material. Using only half the quantity of an insecticide necessary to kill an insect pest gives the same result, and not only so ; but if I use " half the care " necessary to thoroughly wet the leaves of the tree or cover them with the poison, the result may be worse than useless.

It is therefore of the highest importance to ensure efficient and therefore successful spraying, and in the following chapter are set out the conditions necessary for success.

CHAPTER II

HOW TO ENSURE EFFICIENT SPRAYING

Spraying is admittedly an operation which costs money, and inefficient spraying is too costly at any price! What then is the definition of efficient spraying? It is obviously only correctly applied to a method which gives thoroughly effective results with the minimum cost in labour and materials. We may now proceed to consider very briefly what are the essential factors necessary for securing efficiency in spraying.

(*a*) Correctly Diagnosing or Recognising the Disease or Attack.

This requires a wide and intimate knowledge of pests and diseases. Practical experience is, of course, a great asset, but it needs to be supplemented by accurate scientific knowledge, to discriminate between attacks outwardly similar. This is specially true in the early stages of disease or of insect pests, when careful and minute examination with a hand magnifier is essential. In this country we are still considerably behindhand in this matter, and while there are notable exceptions to the rule, it remains a fact that in comparatively few cases is there sufficiently accurate knowledge to distinguish between the different kinds of sucking insects, such as psylla (apple sucker), various species of aphides, the harmless and harmful varieties of red spider. Too often there is a tendency to class all sucking pests as "blight" or "fly," without attempting or desiring to discriminate further. Yet upon such discrimination and accurate recognition of the pest depends in many cases the success or failure of the methods used for control.

Then take the caterpillars. It is quite common knowledge that these form the larvæ or immature stage

of moths (or butterflies) but how many of us are able to distinguish caterpillars resulting from eggs deposited by females which have succeeded in passing the grease bands (or been conveyed to the branches by other agencies) from those which are the offspring of winged female moths ? Yet how is one to decide on the efficiency of banding without this knowledge ?

In the case of fungus and bacterial disease, recognition of the early signs of the trouble is still more important. To take one example out of many, there is the " apple scab " or " black spot " disease, which stunts or disfigures at least half of the fruit sent to market in this country. If this disease is to be dealt with at the right time, it should be recognised on the leaves when the fruit is still immature. In this stage it can be fairly effectively controlled by spraying. Unfortunately, it is safe to say that at the present time either from lack of care or lack of knowledge (exceptions as before) trees plainly showing these signs of disease are allowed to go unsprayed, and as a result the fruit soon becomes infected with very serious results to both the quality and yield of the crop.

If fruit growing is a commercial proposition comparable with manufacture, then it is obviously illogical to expect success when we do not know with any certainty whether our capital (represented by the trees) is reasonably secure, and capable of giving immediate dividends in the shape of good fruit and good profits, or if either of these is in danger, to recognise the cause so as to be able to apply effective remedies.

(*b*) Knowing the Correct Time to Apply the Remedy.

This is almost more important than the recognition of the disease. The old adage of " a stitch in time " applies here very forcibly. In fact, in the case of the greater number of pests and diseases of fruit, if the remedy is not applied at the right time, a hundred " stitches " will not suffice to repair the damage.

The chief reason for this is that—

Insect pests and fungus diseases are, generally speaking, vulnerable (i.e., *open to control by spraying*) *during a particular stage or period only in their life history.*

If we spray before or after this critical period we only waste time and money. Thus no spray at present known is of any use against aphis, psylla, and capsid while in the egg stage, before hatching has taken place. On the other hand, all these are quite easily killed if they can be sprayed when *newly hatched*, and this is in point of fact the most vulnerable period in their life history. A further important advantage is that the pest is few in numbers at such a time, and we have the opportunity of dealing with the " ancestors " instead of the " descendants." Sooner or later, each of these insects becomes protected by entering the buds, and are almost immune from the action of a spray. (The question of autumn spraying of aphis and of cover-washes to prevent successful hatching of eggs will be dealt with later.)

The same is true in the case of caterpillars, only here we are not so much concerned with the pest being inaccessible to the spray at a later date, as with the enormous damage which can be done if not destroyed in the young stages.

In all fungus diseases there is a period when more good results from spraying than at any other time, and in most cases this is in the youngest stage of the disease when the first signs of it appear on the tree or plant. A large amount of good may also be done by spraying during the spore stage in the winter, not because the spores are easier to kill—on the contrary—but because much more powerful solutions can be used without harm to the tree. From the foregoing it is obvious that for spraying to be successful the closest possible watch must be kept for the first appearance of the pest, especially in the *spring*. Daily examination of the young buds and shoots with a powerful hand-magnifier is advisable at this critical period.

(*c*) Selecting the Right Type of Remedy.

This is a matter where many mistakes in the past have been made. There are several distinct types of remedies which should be carefully distinguished, *e.g.* :

1. Contact poisons.
2. Stomach poisons.
3. Corrosive poisons.
4. Fumigants.
5. Preventives.
6. Fungicides.

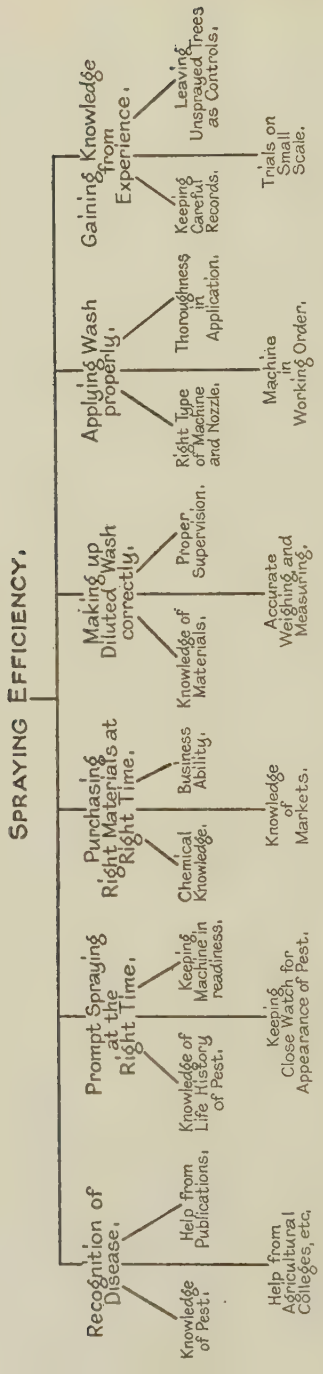
1. Contact Poisons are used against *sucking insects* which feed upon the sap of the plants, such as aphides, psylla (apple and pear suckers), capsid, etc. Generally speaking, they are soluble or emulsifiable insecticides used in a solution of soap or other "spreading" agent. It is of no use trying to kill such pests with insoluble stomach poisons such as arsenate of lead, as the leaves are not eaten.

2. Stomach Poisons are employed against *chewing insects*, which actually eat the leaves or tissues of the plants, such as caterpillars, beetles, and some weevils. The poison must usually be in an *insoluble* condition, so as not to injure the leaf, and is sprayed so as to cover as much as possible of the leaf surface. Many soft-bodied caterpillars can also be killed by a contact poison, if they are sufficiently exposed on the leaf or stem to be thoroughly wetted by the spray.

3. Corrosive Poisons have a burning and destructive action on the skin of the insect or eggs, and can, generally speaking, only be used in the winter or dormant season.

4. Fumigants act in the form of gas or vapour, and can normally only be used either in an enclosed space, like a glass-house, or in the soil. They may be either gases such as hydrocyanic acid gas, liquids in the form of vapour, such as nicotine, carbon bisulphide, etc., or solids which emit vapour, such as naphthalene.

5. Preventives.—These need to be applied before the insect is present in an active form, usually with the idea of stopping the pest from reaching the leaves and shoots. Lime used as a cover wash in early spring and banding composition to prevent wingless female moths and other insects from crawling up the trunks are instances.



6. FUNGICIDES.—These have a specific poisonous action on fungi. Very few are known at present, the only active ones consisting of compounds of copper or sulphur, free or in combination. They apparently act as contact poisons, although flowers of sulphur is probably to some extent a fumigant. If used in the growing season, they must be in a very dilute form, but during the winter may be sprayed at much higher strength.

(*d*) Purchasing the Most Efficient Grade of Material at the (comparatively) Cheapest Price.

This is admittedly a difficult matter in many cases, and experience is usually the only really safe guide. It is of no use trusting to advertisements of manufacturers in deciding the best and most efficient grade of material in any given case. There is, however, a distinction to be made here between what may be called *standard materials* of fairly definite chemical composition, such as arsenate of lead, lime sulphur, etc., and *proprietary preparations*. In the former case it is desirable to know the strength of the preparation, while in the latter one's own experience or that

of others, and above all the repute of the manufacturer, are the only safe guides.

Lime sulphur is now sold of a definite specific gravity, usually standardised by the makers at 1·3 S.G., which means that one gallon of the liquid weighs 13 lb. Although in " straight boiled " lime sulphur this is a reliable guide to the strength for spraying purposes, it should be remembered that it is possible to manufacture a relatively weak lime sulphur, which yet would conform to this specific gravity. Hence again the desirability of purchasing from manufacturers of known standing and repute.

In comparing the cost of washes, the dilution recommended by the manufacturers should always be noted and calculations made on the basis of the cost for a definite volume of made-up wash, say, 100 gallons. Thus, if a given proprietary wash costs, say, £14 per barrel, and is used at a strength of one gallon to 100 gallons of water, the cost per 100 gallons (assuming the barrel holds 40 gallons) is 7s., and is actually cheaper than a wash costing £11 15s. a barrel, to be used at a strength of one gallon of wash to 80 gallons of water, where the cost of 100 gallons is approximately 7s. 4d.

(*e*) Applying the Remedy in the Correct Form.

Insecticides and fungicides are seldom purchased ready for spraying. They either need dilution with a definite proportion of water, or require to be used with a solution of soap or some other substance as a " spreader " or " wetting agent." It is advisable whenever possible that skilled supervision should be given to the preparation of the diluted wash not only to see that the quantities are correct, but to make sure that the substance is completely dissolved or uniformly mixed. In the case of sprays containing soap, there is, however, an important factor to take into consideration, neglect of which has been responsible for a great deal of ineffective work. This is the question of the " hardness " of the water. The writer hopes to show later on how growers can be assured of efficient results when using water of any degree of hardness.

Many growers use a mixture of two or more substances as a composite wash, and where this is practised as a result of experience and is carried out under careful supervision, it is quite without objection. There are, however, many pitfalls to be avoided when two or more chemicals are mixed together, and even where good results apparently follow, it is questionable, for reasons which will be considered later on, if true efficiency is obtained.

(*f*) Applying the Remedy in the Right Manner.

A cause of much failure in spraying lies in the method of application, which is often left to semi-skilled operators, and in consequence insufficient spray is used, or the trees or plants are not sprayed with consistent care throughout the plantation, which results in "patchy" work. One cannot too strongly emphasise the futility of exercising due care with regard to all the foregoing factors, and leaving the application of the wash itself to take its chance in more or less unskilled hands. Many large and successful growers personally supervise their spraying and follow the machine, to see that the leaves (or in winter, the branches) are thoroughly wetted. Having done this, they are in a position to decide by subsequent examination of the trees whether the wash is killing efficiently, and if not, make such changes as may be desirable.

A further point in this connection is the use of a different character of spray nozzle for contact and for poison washes, a matter which will be referred to later.

(*g*) Ensuring Freedom from Damage.

If spraying is carried out with suitable materials in a proper manner, there should be but little chance of damage to the crop. Statements have been made to the effect that all spraying is more or less injurious. This is not the writer's experience. On the contrary, the destruction of the pest, which follows on efficient spraying, rapidly improves the condition and health of the tree or plant. When serious damage occurs after spraying with an approved

wash, the presumption is that either the materials were impure, the solutions used were too concentrated, or the trees were sprayed at an admittedly susceptible time, *e.g.* when in blossom. Damage may also occur when two quite harmless substances are mixed which react with one another chemically; hence the danger when "mixed" sprays are used without adequate knowledge. Of course some substances are known to produce injury in certain circumstances, as Bordeaux mixture on tender varieties of apples, etc. Certain weather conditions, also, are unsuitable for spraying, and others conducive to efficiency, but with these exceptions, the foregoing remarks hold good.

(*h*) Conducting One's Own Research.

Since no two plantations are exactly alike in all respects as regards soil, situation, cultivation, vitality of trees or plants, etc., it follows that, although great profit can accrue from making use of the experience of others, there is nothing to equal knowledge gained from one's own practice. It is quite a simple matter to reserve a few trees or plants for experiment with different washes, or with varying concentrations of the same wash, and, if careful records are kept, the information so obtained will be found increasingly useful as it accumulates. Whether this is done or not—and it is not suggested that it can be carried out in every case—it is, at any rate, an easy matter when spraying to leave one or two trees or plants *unsprayed*, to act as "controls." An examination of these alongside those sprayed will then prove without question what effects are to be attributed to the wash used, and what are due to purely natural causes, and a correct judgment of the efficiency of the spray is rendered possible.

CHAPTER III

SPRAYING WITH AN OBJECT

In a previous chapter the importance of being able to "spot" a pest or disease on its first appearance was referred to. If we would spray intelligently, it is almost of equal importance to be able to recognise the kind of injury produced by various pests on the mature fruit, and to distinguish this from the results of purely physical agencies which are not under our control. On several occasions the writer has received samples of injured fruit from growers, with the suggestion that the spray they were using had not done its work. On examination it was found that in each case the injury was not due to any insect or fungus, but was caused by frost (see Fig. 7). In order to assist in the recognition of damage, which it is neither possible to control by spraying, nor feasible to prevent by other means, the attached photographic reproductions are given, illustrating the characteristic injuries due to natural causes.

Fig. 1 shows a well-formed apple with a sound and healthy skin. In Fig. 2 the skin shows disfiguring marks caused by friction against a branch or another apple, as will occur in windy weather. Fig. 3 shows another kind of injury due to the same causes, when the fruit was less developed, and resulting in a corky roughening of the skin. In Fig. 4 the fruit has been severely bruised by the impact of a hailstone, and Fig. 5 shows the resulting rot which sets in, due to the entrance and growth of fungus spores. The flattened, discoloured area in Fig. 6 is due to "sunburn," and is often the result produced by the action of direct sun after a shower, a rain-drop adhering to the skin of the fruit probably acting as a lens or "burning glass" in concentrating the rays of the sun. Fig. 7 shows a characteristic example of frost injury, usually occurring round the

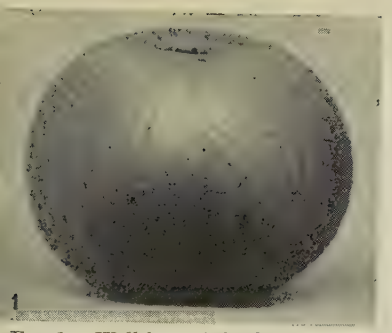


FIG. 1.—Well formed, healthy apple.

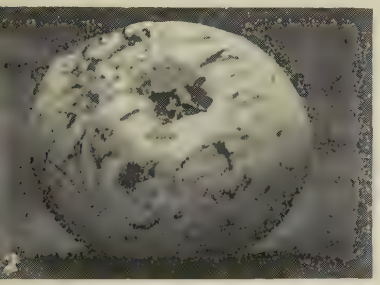


FIG. 2.—Skin of apple marked by contact with twig, branch, etc.

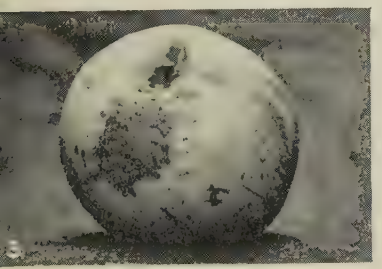


FIG. 3.—Corky roughening of skin caused by friction.

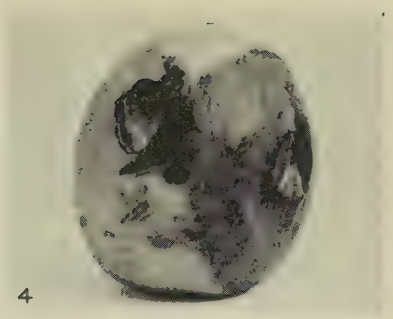


FIG. 4.—Hailstone injury.

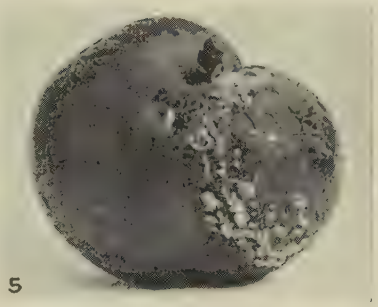


FIG. 5.—Fungus rot resultant on puncturing skin.

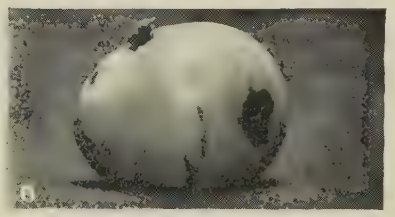


FIG. 6.—Injury due to sunburn.

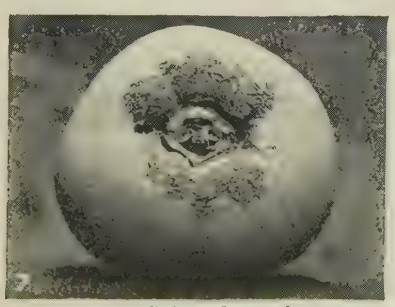


FIG. 7.—Injury due to frost.

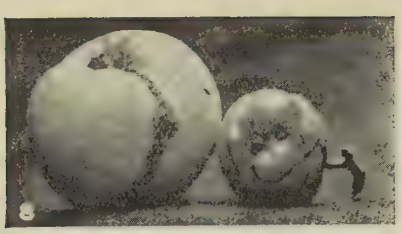


FIG. 8.—Disfigurement caused by caterpillars.

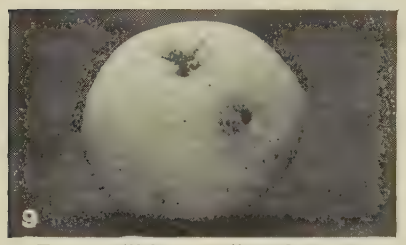


FIG. 9.—"Maggotty" apple due to codling attack.

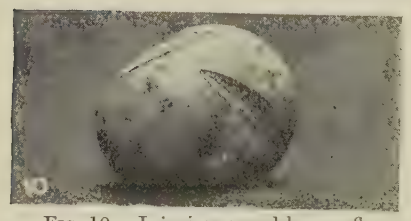


FIG. 10.—Injuries caused by sawfly maggot.

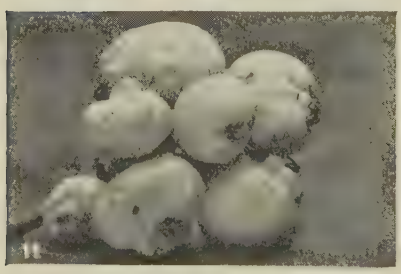


FIG. 11.—Distortion and stunting resultant on aphis attack.

FIG. 12.—Scars, distortion and under-development due to capsid-bug attack.

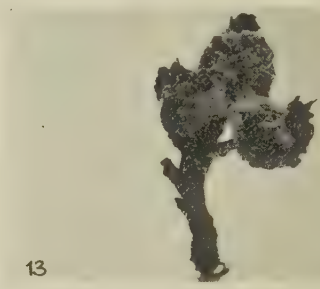


FIG. 13.—Fruit attacked by the brown-rot fungus.

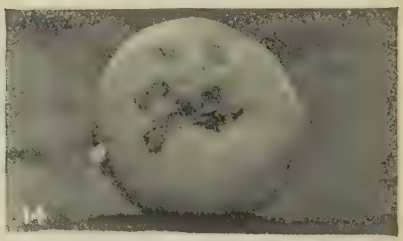


FIG. 14.—Blotches caused by the apple-scab disease.

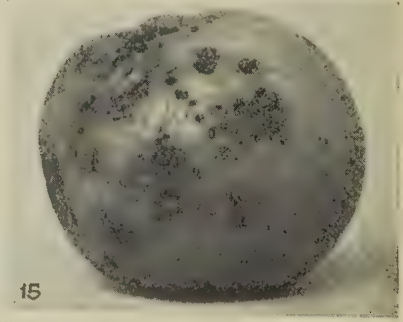


FIG. 15.—A typical example of apple scab (Black-spot) disease on apple.

eye of the apple, and resulting in the formation of corky scales and cracking of the skin.

Coming now to injuries caused by the action of insects and fungi, it is very essential to distinguish, from the outset, between pests which cause : (1) Injury and disfigurement of the fruit ; and (2) loss to the fruit crop ; and some which neither injure the fruit nor kill the blossom, but which produce general debility of the tree or plant by destroying the leaves or removing the sap.

There is, in this country, a very general recognition by growers of the vital necessity of controlling pests of the second class, viz. those which kill or injure the buds or blossom, and so prevent the formation of the fruit. What is not so generally realised is the importance of producing fruit of clean and healthy growth, free from distortion and blemishes of the skin. The result is that a very large proportion of fruit sent to market is of a low grade, comparing most unfavourably with the imported article, and this is the more unfortunate, as our English varieties of fruit, and especially of apples, are easily superior both for cooking and dessert to anything produced abroad. The writer is firmly of the opinion that a greatly increased consumption of fruit—especially the dessert varieties—would follow, if the general average condition could be improved, to the great benefit, both of the grower and of the general public. That there is nothing insuperable about the production of clean, healthy fruit of good grade has been proved over and over again by growers who have taken over neglected orchards, and instituted good cultivation and scientific methods of control of pests.

A very necessary first step is for a grower to inform himself as accurately as possible of the particular pests which are responsible in his own case. These may vary to some extent from year to year, but a careful examination in any one season will be an excellent guide for treatment during the following year. Further, although it may in many cases be a difficult matter to " spot " a pest or disease on its first appearance, it is comparatively easy to recognise it from the injuries to the mature fruit. The accompanying

illustration may be of assistance in deciding which pests have caused damage to apples in a given case.

Without any doubt at all the worst enemy of the grower in this connection is the **apple scab** (or black spot) disease. Very few orchards in this country are entirely free from it, and it not only disfigures the fruit to a greater or less extent, rendering it in mild cases unattractive, and in bad cases quite unmarketable, but it produces stunted and distorted apples, of poor quality, lacking in juice and flavour. The disease is pretty generally recognised. It occurs on the fruit as greenish black spots, which increase in size and form scabby patches, due to the death of the skin. Noticeable distortion and bad cracking occur in severe cases, the latter especially in the case of the corresponding disease on pears. Figs. 14 and 15 show typical scab disease on apples.

Attacks by **aphis** are probably next in importance in the detrimental action on the fruit. Fig. 11 shows a typical case of disfiguring and distortion, due to **aphis** attack. An enormous number of apples were affected in this manner last year, and in many instances they were rendered quite unsaleable and useless. There are several species of aphis which attack apples, but by far the worst and commonest of these is the so-called blue apple aphis (*Aphis malifoliæ*) and the injury shown is practically always due to this species.

In the Cambridge district, the worst enemy of apple-growers for some years has been the **capsid bug.** It produces fruit scarred in the characteristic manner shown in Fig. 12. In addition a great many apples fail to come to maturity, and a severe attack often results in such bad disfigurement as to involve a total loss of crop, which is only fit to be fed to pigs. Kent and Worcester growers should keep a sharp look-out for the appearance of this pest, as once it establishes a hold, it is extremely difficult to control. Attacks have already occurred in parts of Worcestershire and Hereford.

Fig. 10 shows injury caused by **sawfly**. It is probably produced by the unsuccessful efforts of the maggot to enter

the fruitlet through the tough skin. The familiar maggoty apple, known and recognised in ancient times, is shown in Fig. 9. It is, of course, due to the **codling moth**, which, although seldom seen, is responsible for an immense amount of injury. Generally speaking, the entrance hole of the maggot is in the eye of the apple, but in certain cases there may be a second brood which penetrate through the side. The maggot feeds at the core of the apples, and always makes an exit hole at the side. It may or may not be within the apple when marketed. Such " wormy " apples, although they often appear in the shops, are a very bad advertisement, both for the retailer and for the producer. Fortunately, it is possible to control this pest if the right method is used and the correct time strictly adhered to (see below).

Although **caterpillars** cause damage chiefly by devouring the leaves and blossom buds, they occasionally cause disfigurement to the fruit in the manner shown in Fig. 8.

The **Brown Rot Disease** affects apples so badly that there is never any question of their being fit for sale. They continue to hang on the tree in a dried-up condition if not plucked off (Fig. 13). The disease often, however, affects apples in the store-room, and spreads rapidly if the affected fruit is not removed.

Remedies for Pests which Injure or Disfigure Fruit.

1. Apple Scab.—(*a*) When the disease is firmly established, spray with lime sulphur, 1·3 specific gravity: (1) Before bursting of buds, at winter strength (1 in 20); (2) immediately after fall of blossom (1 in 60); (3) two or four weeks later (1 in 60). Remove any blistered shoots from trees in winter. (See page 105.)

(*b*) As a preventive, spray with lime sulphur, 1·3 specific gravity, before bursting of buds, at 1 in 20. Examine young leaves, and, if signs of the disease appear, spray soon after fall of blossom with 1 in 60. (See page 113.)

Some varieties of apples will not stand the 1-*in*-60 *strength*

solution, which results in a leaf fall. If in doubt as regards a particular variety, growers should consult their nurseryman.

2. Blue Apple Aphis.—(*a*) Spray before the leaves curl with soft soap and an efficient contact insecticide,[1] or good proprietary fruit wash. (*b*) Spray in same manner in autumn when egg-laying females appear upon the leaves. (See page 133.)

3. Capsid Bug.—Spray with a suitable contact wash [1] as soon as signs of the newly hatched bug appear on the trees. Continue at intervals until no further signs of hatching appear (total hatching period, usually 2-3 weeks). (See page 135.)

4. Sawfly.—No direct remedy at present known. Keeping poultry in the orchards from May to July has been found very beneficial.

5. Codling Moth.—(*a*) Spray with arsenate of lead not more than seven days after petals have dropped from blossom. (See page 139.) (*b*) Tie sacking round trunk of tree in early summer to provide shelter for caterpillars. Remove and destroy in September.

6. Caterpillars.—Spray on first sign of appearance with Derris [2] in the form of powder or as a liquid, using sufficient soft soap to form a good lathering solution. This is a non-poisonous spray with a specific poisoning action on caterpillars, and may be safely used without removing animals grazing in the orchards. (See page 115.) Arsenate of lead is the best poison spray to use, but must be handled with care, and stock should be removed during, and for some time after, spraying. The best form to use is a finely-divided, easily miscible arsenate powder. (See page 54.)

7. Brown Rot.—(*a*) Remove diseased fruit from tree. (*b*) Cut off diseased spurs in winter. (*c*) Spray with lime sulphur, 1·3 specific gravity (1–20), before buds burst in spring. (See pages 107 and 113.)

[1] See Chapter XII.

[2] See pages 109, 110, 115.

CHAPTER IV

TACTICS OF WARFARE AGAINST INSECT ENEMIES

One of the first essentials of successful warfare is to keep an unremitting watch for signs of the enemy, and when he is "spotted," to ascertain by careful observation his numbers, strength, and exact location. The next step in the science of tactics is to open a vigorous offensive on the enemy before he has time or opportunity to entrench himself, and while he is still "in the open." Once he has "dug himself in" the case becomes largely hopeless.

Precisely the same reasoning applies most aptly in the case of our insect enemies. If we would put up a successful fight, it is of the first importance to keep the sharpest possible lookout for the first appearance of the pest. During the months of early spring the trees or plants should be kept under the closest possible skilled observation. There are several very cogent reasons for this, well known to those who have studied the question. They are as follows :—

(1) Almost all the pests of fruit are in early spring in the egg stage, in which they are practically immune from attack.

(2) The sucking pests (aphis, psylla, etc.) are relatively fragile, and easily killed when newly hatched, being exposed naked on the exterior of the opening buds.

(3) They soon enter the buds, become strongly entrenched, and are again practically immune from attack.

(4) The leaf-eating pests, chiefly caterpillars, are also readily killed when newly hatched by a suitable contact wash.

(5) If not killed when young they are capable of doing an increasing amount of damage out of all proportion to their rate of growth. The food should, therefore, be baited with poison in good time, so that, if possible, they get a dose of it with their first meal.

Now, although this advice to keep a vigilant watch for the newly hatched pest, so as to be able to deal summarily with it, is pretty generally followed in America with excellent results as regards the health and performance of the trees, it is less often acted upon in this country. In view of the great importance of this matter, it seems desirable to consider at some length the reasons for our present English practice.

In the first place, it is probable that many growers do not realise the importance of spraying at this particular period, and do not therefore keep a close watch for the pest, which they otherwise would.

Secondly, a great many, probably the majority of growers feel very disinclined to spray until the leaf buds have definitely opened. They would consider that a great waste of spray fluid would occur by spraying at this stage. This is largely a fallacy, as will be admitted when it is remembered that many of those who hold this opinion are amongst the most enthusiastic believers in winter spraying.

Newly Hatched Insects.

Probably, the chief reason for our not adopting the American practice of early spraying is on account of the very mixed character of our English orchards. In America large acreages are planted with two or three varieties, so that it is possible to spray on a large scale trees which are in a uniform stage of growth and development. Over here late and early varieties are intermixed, even in small plantations, and it involves careful observation to find trees which have arrived at the optimum condition for spraying. A great deal must therefore be left to the judgment of the foreman in charge, and in many cases it becomes, in real life, a difficult matter, quite impracticable in certain instances. Notwithstanding this, the advantages of spraying the newly hatched insects cannot be too strongly urged where trees of a given variety are planted in rows and so readily kept under observation, and convenient for treatment.

As regards the actual recognition of the pest, it is not

possible in the limits of this treatise to do more than touch upon the matter. The illustrations (Figs. 16 and 17) may

Fig. 16.—Newly hatched aphis on twig of apple.

Fig. 17.—Newly hatched aphis on young leaves.

help to show how newly hatched insects (aphis in this case) appear upon the young leaves and developing buds. Even those with the keenest eyesight will find it an advantage to use a fairly powerful pocket magnifying glass, preferably of the Coddington type, which is made from a spherical lens, ground into cylindrical form, and grooved in the centre to form a stop or diaphragm. With such a lens, the newly hatched aphis appear as in Fig. 18. Newly hatched apple suckers are much flatter and wider, with shorter and stouter legs and bodies of a bristly appearance. Very young

Fig. 18.—Newly hatched aphis on young leaf—magnified.

caterpillars are small, but readily recognised under the magnifying glass.

In the case of psylla, it is generally of little use to spray at a later date. If many suckers are present in the flower buds these fail to open, and a withered truss is formed. As regards aphis, the most destructive species produce tight curling of the leaves, in which they are effectively sheltered from attack.

Autumn Spraying.

Assuming that spraying has been neglected at the only time in spring when it is effective, *e.g.*, when the aphis and psylla are newly hatched and exposed to attack, is there any remedy? The answer to this is, clearly, that no subsequent spraying for these pests is of much use during the season, while in midsummer the blue aphis—by far the worst of these pests on the apple—completely disappears. By this time the suckers have also reached the winged-adult stage, and are apparently harmless.

There is, however, a period in early and mid autumn when both of these pests are again open to attack. This fact has been repeatedly pointed out by various scientific authorities, but the writer has yet to hear of cases where growers are acting upon the advice given. This is probably due to the fact that when the fruit is mature, the tendency is to lose interest in the matter, since no immediate advantage is derivable at such a time.

This is, surely, a very short-sighted view, and growers would do well to adopt in this respect the same policy that has been very widely employed in the case of the destructive winter-moth caterpillar. I refer to grease banding—an operation carried out in the autumn to catch and destroy the adult insects and so prevent egg-laying and subsequent infestation of the trees with caterpillars in the following spring. Why observe this wise precaution in the case of one pest and neglect it in the case of another equally or, in some instances, more harmful? It would certainly

seem that the facts of the case are not yet generally recognised.

If we examine the leaves of our apple trees in late September and October, we will often find considerable numbers of aphides, and frequently some adult suckers

Fig. 19.—Aphides laying eggs on apple leaves in autumn.

also. Winged forms of the aphis appear first, and these are the "migrants" which have returned from their summer haunts back to the apple. They give rise to egg-laying female lice and males. (See Fig. 19.)

Now, the special point about spraying at this time is that *no curling of the leaves takes place*. The flies and lice remain for a considerable time fully exposed on the

surfaces of the leaves, and on the stems and shoots. Further, at this stage, the tree is in a semi-dormant condition, and slight injury to the old leaves is of no moment, consequently, *a strong contact wash can be safely applied* to ensure complete destruction of the pest. Many psylla

Fig. 21.—Magnified view of aphides and eggs.

Fig. 20.—Twig in late autumn, showing result of activities of egg-laying aphides.

may be destroyed in the same manner. The result of leaving the pest in undisturbed possession is shown in Fig. 20, and a magnified view in Fig. 21. After a few weeks shiny, black particles appear in large numbers on the shoots and angles of the buds. These are the eggs, and the insect is now once more in a perfectly safe phase of its life-history,

since no wash is known which can be relied upon to destroy the eggs without injury to the tree.

The moral is obvious.

The following diagram (Fig. 22) may serve to present the argument in a clear and graphic manner :—

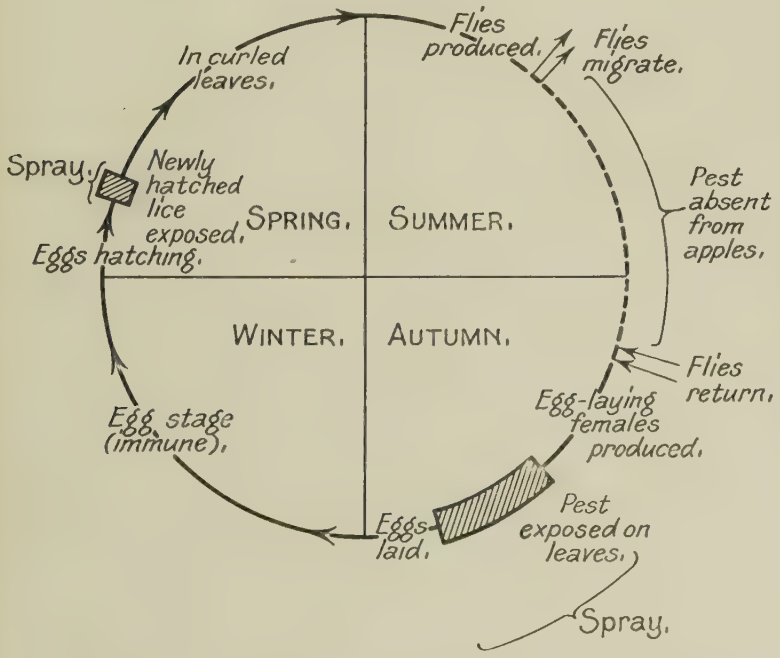


FIG. 22.—Diagram of life-history of blue apple aphis.

The shaded portions indicate the length of time available for spraying the pest while exposed on the plant.

CHAPTER V

DESTROYING THE SAP-FEEDERS

A WELL-KNOWN and highly successful business man recently stated that he attributed his prosperity to accurate and detailed knowledge of his business, and the skilled use of scientific methods adapted to his own particular case. Efficiency has been often defined in almost the same words. In the subject under present discussion, this accurate knowledge is only attainable by a careful consideration of the peculiarities of each of the insect enemies against which we wage incessant warfare. Then, and only then, shall we be able to select the particular weapon most appropriate in a given case, and use it in the most effective manner.

Consideration of such peculiarities leads to classification, and the most useful classification for the practical grower is one made from the practical standpoint. For scientific purposes the insects are classified on the basis of the number and character of their wings which, except as a means of recognition, is a matter of little moment to the practical man.

It may not be easy to define exactly the best basis for a practical classification, but the writer submits that the basic facts of importance to the grower are :

(1) Whether the insect eats the tissues of the plant or sucks its sap.

(2) Whether it lives on the exterior or in the interior of the plant.

(3) Whether it is normally above or below ground.

Each of these are prime factors governing the methods which must be employed in combating the attack. On this basis we can distinguish six different classes of insect pests :

(1) Sucking insects openly feeding above ground.
(2) Eating insects openly feeding above ground.
(3) Sucking insects feeding on the roots.
(4) Eating insects feeding on the roots.
(5) Insects feeding in the interior of the trunk, stem, leaves, or fruit.
(6) Insects feeding within the roots.

It should be noticed that in this practical classification

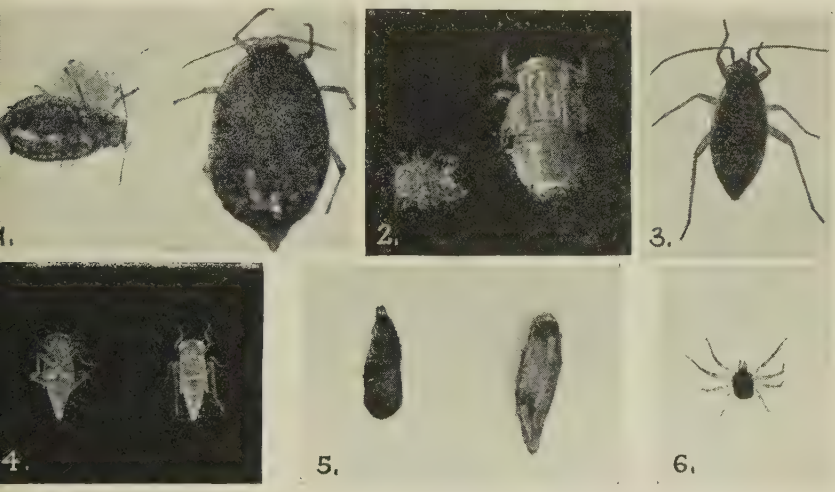


FIG. 23.—Typical "Sap-feeders."—1. Aphis. 2. Psylla. 3. Capsid bug. 4. Leaf hopper. 5. Scale insect. 6. Red spider.

we are not concerned as to whether the insect is in the larval (immature) or the adult stage. In fact, an insect may be a pest in one class in the young stage, and in another when fully grown. Further, cases are known where insects feed both above ground and in the soil, such as the woolly aphis.

Dealing now with the first of these divisions—those sucking insects which feed on the exterior of the plant above ground. In Fig. 23 (1–6) are shown typical photographs of the more important of these. They all feed by imbibing the sap from the tissue of the leaves, buds, etc., through a specially formed beak, which is hollow and tubular (see Fig. 24).

No. 1, Fig. 23, shows a typical aphis (plural *aphides*). This insect is by far the most commonly occurring of all sucking pests, and attacks almost all known plants. It is frequently present in such vast numbers as to almost cover the entire leaf or stem surface. No. 2 shows the apple sucker (psylla)—the pear sucker is very similar—which does not usually occur in large numbers, but is specially injurious, as it enters and destroys the young flower-buds. The capsid bug, No. 3, is distinguished by its size and activity. As previously mentioned, it is at present confined in this country to the Cambridge and Worcester fruit-growing districts.[1] The hopper is the least frequently occurring and least dangerous of the sucking pests (No. 4).

FIG. 24.—Typical aphides, showing "beak" or "sucking tube."

Scale insects (No. 5) differ from the other suckers in being protected under the "scale" or shell-like structure which completely envelops the mature insect. Special means have to be adopted to fight this pest, and it therefore forms an exception to the rest from the point of view of treatment. Red spiders (No. 6) may be harmless or injurious. They are not strictly insects, as they belong to a lower order of life, but they cause injury in the same manner by sucking the sap of plants.

Sucking pests are destroyed by means of contact insecticides, of which by far the most effective is *Derris*[2] in one or other form. This insecticide has come to the front in recent years, and is gradually displacing nicotine, the

[1] Reports of its occurrence in certain parts of Kent have recently been received by the writer.

[2] See page 109.

alkaloid contained in tobacco. Derris has the special advantage that whilst being very deadly to insects—not only of the sap-feeding type, but also to most of the leaf-eating varieties—it is harmless to human beings and warm-blooded animals. It may thus be used upon fruit and vegetables which are shortly to be eaten.

Nicotine [1] is also a good destroyer of sap-feeding insects, but it is relatively expensive, and as it is a very deadly poison, needs handling with the greatest caution. Emulsions of various oils have in the past also been used for this purpose, but are not to be recommended for use except during the dormant season owing to the extreme risk of damage to the foliage and plant.

Fig. 25.—Plum leaf covered with "mealy" aphides.

Sucking insects may also be destroyed by coating the body with a fine powder which contains a suitable insecticide which is absorbed by the body of the insect, and in the case of plants enclosed under glass, it is possible to surround the entire plants with a poisonous gas.

In wet spraying against sucking pests, which is the commonly employed method, the first essential is to ensure that the entire surface of the body of the insect is wet by the spray. This is by no means as easy as it sounds to the uninitiated, since all aphides possess a skin which resists the action of liquids. Some are coated over with a waxlike substance, *e.g.*, the mealy plum aphis, seen on the leaves in Fig. 25, and highly magnified, showing the wax in Fig. 26. If water is sprayed on such an infested leaf it will not wet or adhere to any extent at all. Other aphides secrete a sticky substance, which adheres to their bodies and resists the action of water in a similar way (Fig. 27).

[1] See page 111.

FIG. 26.—Mealy plum aphides (magnified) showing waxy "meal."

FIG. 27.—Typical aphides enlarged, showing water-resisting coating of bodies.

Furthermore, most leaves are very difficult to wet with plain water. As, therefore, the entire action of the spray depends upon the contact of the insecticide with the skin of the insect, it is quite useless to expect good results unless an efficient covering or wetting of the leaf and of the pest is ensured.

It has long been known that what are termed "spreading"

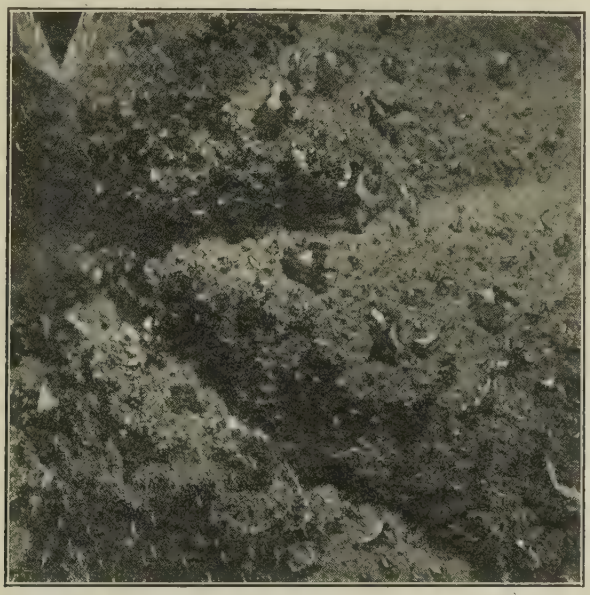


FIG. 28.—Magnified view of leaf sprayed with plain water.

substances are able to produce this wetting action. Chief amongst these, and without doubt the most effective, is soap. This is clearly seen in the enlarged photograph of a leaf surface shown. In Fig. 28 plain water was sprayed up the plant until some of the drops adhered. On magnification, it is seen that the water occurs in isolated drops which, if the leaf were shaken, would drop off, leaving the surface dry.

Fig. 30 shows the result of the addition of soap to the water. The leaf surface is now uniformly wet, and any sucking insects would be similarly coated with the liquid.

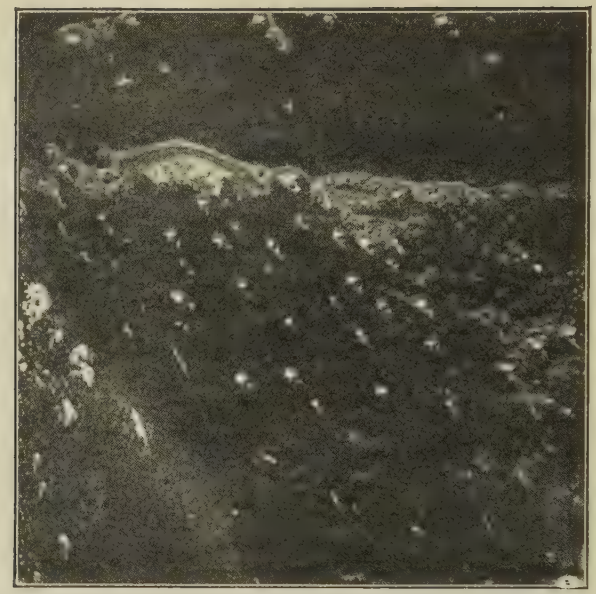


FIG. 29.—Enlarged view of leaf surface sprayed with insufficient soap to "kill the hardness."

FIG. 30.—Leaf surface enlarged, showing the perfect wetting obtained with soft soap in sufficient quantity.

This is the first essential condition of successful spraying for such pests.

In Fig. 29 we have the result of insufficient soap to produce wetting, and only a partial covering of the leaf occurs. Much of the inefficiency of practical spraying to-day is due to this cause. The amount of soap necessary for efficiency

Fig. 31.—Aphides sprayed with a wash containing insufficient soap to kill the hardness of the water. The spray adheres in drops on the bodies of the insects, but does not flow over or "cover" them (highly magnified).

varies according to the *hardness* of the water, a subject which will be considered in a later chapter.

In Figs. 31 and 32 is shown the actual result on the bodies of the insects. In Fig. 31 the wash is seen to adhere in drops (made visible by the use of a coloured solution). In Fig. 32 complete wetting is obtained.

Other colloidal substances, though not so effective as soap, are with advantage employed in special cases. Thus,

flour paste has been advised against red spider and calcium caseinate with lime-sulphur solutions, where soap would be useless, as it is converted into an insoluble lime soap.

The most suitable soap for spraying purposes is the variety known as soft soap. The difference between soft soap and ordinary bar soap or toilet soap is, that while the

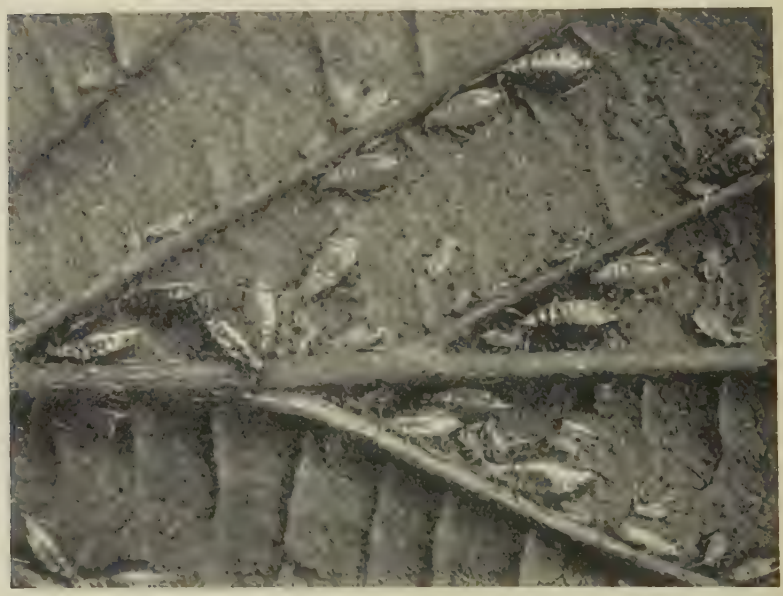


Fig. 32.—Aphides sprayed with a wash containing sufficient soap to destroy the mineral salts causing the hardness of the water, and so soften it. The bodies of the insects are "covered" by the wash and completely wetted, ensuring an efficient result (magnified).

latter is made with caustic soda, for soft soap caustic potash only is employed. During the war a substitute soft soap was largely used, which contained no potash, this being then unobtainable. By the use of certain selected oils, a transparent material of a soft consistency was obtained, which resembled true potash soap very closely.

Soft soap can be manufactured from almost any animal or vegetable oil or fat, but the best soaps are made from the finest grades of vegetable oils. The oil and the caustic

potash solution are boiled together with a current of steam, and the process requires a considerable degree of skill, as otherwise a good product is not obtained. A small excess of caustic potash, up to about half of one per cent., is an advantage, and is not injurious when ordinary water is employed, as it helps to kill the hardness. A proportion of carbonate of potash is also usually employed, as it helps to produce a clear soap, more easily soluble in water than it otherwise would be.

Only high-grade soft soaps, made by reputable manufacturers, should be used for spraying.

Soft soap is valued, other things being equal, on its percentage of fatty acids. This is a measure of its strength, and it is determined by dissolving the soap in hot water, and treating it with a mineral acid, such as sulphuric acid. The action of the acid is to set free the fatty constituent of the soap, which separates from the solution, and may be collected and weighed.

As soft soap is almost insoluble in cold water, it is boiled with about ten times its weight of water, and the strong solution so formed is diluted with the requisite quantity of cold water to form the spraying liquid. To this diluted soap solution the insecticide is added, or, if quassia is used, the chips are often boiled with the soap. Manufacturers supply concentrated washes containing the soft soap already in liquid form with the insecticide added, and such need only to be dissolved in the requisite quantity of water to be immediately ready for spraying.

In Chapter XV., page 133, is given detailed description of sucking pests attacking fruit, and further remarks on their destruction.

CHAPTER VI

CONTROLLING THE LEAF-EATERS

The commonest and most generally recognised of all leaf-eating pests are the *caterpillars*. Sawfly larvæ are often mistaken for caterpillars, which in many cases they very closely resemble. As, however, the adults of each belong to distinct classes, it is preferable to distinguish these latter as "maggots" in common with all fly-larvæ. Other leaf-eaters include certain beetles and weevils which occur only rarely on "top fruit."

Although it is quite possible to kill leaf-eating insects, especially the soft-bodied ones, by spraying with a wash con-containing a contact poison, it is the more general practice to use a spray which leaves a coating of poison on the plant. Sooner or later a fatal dose is taken along with the food, and death is therefore, practically certain, provided the poison remains in sufficient quantity on the tree, is evenly distributed, and is of sufficient potency. Against the use of stomach poisons for such pests, it may be argued that a certain time is bound to elapse before the caterpillar or other pest ceases to eat the leaves, and during this time damage continues to be done, whereas an effective contact poison commences to act almost immediately. This is certainly correct, and it is a fact which should be borne in mind, but it is equally true that a contact poison can only act when the insect is actually "hit" or wet with the poison, and this is a difficult matter in the case of many caterpillars and similar pests which have a knack of effectively concealing themselves inside a rolled leaf or between two leaves tightly spun together. In the case of a stomach poison, provided this is sufficiently adherent not to be washed off by rain or blown away with the wind, the bait remains effective, and operates sooner or later with certainty.

Derris.

An exception to the above is in the use of the contact insecticide known as *Derris*. The active principle of Derris is very deadly to nearly all caterpillars, and apparently acts both by absorption through the skin (as a contact insecticide), and also as a stomach poison. It is specially valuable in the case of vegetables, and when spraying fruit which is ripening, as, being quite without action on warm-blooded animals, it is greatly to be preferred to poison washes in such cases. Derris should be used in a solution of soft soap to obtain the best results (see page 115).

Suitable Poisons.

As regards the use of suitable poisons, the consideration of primary importance is that the substance used must be harmless to the plant. For this reason it is preferable that an insoluble material be employed, since the surface of the leaf, unlike the digestive juices of the stomach of insects, has little power of assimilating or absorbing such poisons. A second important requirement is that the poison employed be of such a high degree of potency that a very minute quantity only is necessary to constitute a fatal dose. This is very essential, because the amount which it is practically possible to place on the leaves is very minute indeed.

The only suitable substance which has been found in practice to fulfil the two conditions at all satisfactorily is one of the several possible insoluble compounds of arsenic.

Almost the first to be tried was the substance known as *London Purple*, which was a waste product of dyeworks, and consisted principally of an arsenite of calcium. It was found unsatisfactory, being liable to vary greatly in composition, and, owing to its comparative solubility, likely to cause severe scorching of the leaves of most plants. Another compound of arsenic which had, and still has, a certain vogue is the emerald-green dye known as *Paris Green*. Chemically this substance is an aceto-arsenite of copper, and is, perhaps, the most poisonous substance which it is possible to employ, so that it admirably con-

forms to the second of the two essentials stated above. Unfortunately it also is very liable, under certain conditions, to cause serious injury to the leaves, and for this reason has nowadays few advocates.

The Arsenates.

Calcium arsenate (not to be confused with *arsenite*), although it has the advantage of being the cheapest form of arsenic which is effective as a poison, has been proved by practical trials on an extensive scale to be extremely liable to cause scorching of the foliage. It cannot, therefore, be recommended for spraying fruit trees.

Undoubtedly the most satisfactory of all the compounds of arsenic for spraying purposes is *Arsenate of Lead*, and this substance is now employed all over the world to the practical exclusion of other stomach poisons. It should be free from all but traces of soluble arsenic, a condition which is easily fulfilled when manufactured in the proper manner.

Importance of Fine Division.

An important requirement of arsenate of lead is that it should, when mixed with water, remain in fine suspension for as long as possible. If this is not the case, a uniform coating of the leaves is not possible, and certain areas of the leaves and shoots will fail to be covered at all. Another practical point of great importance is that, unless the arsenate remains in suspension reasonably well, the first trees sprayed will receive an undue amount of the poison, and the remainder hardly any at all. Efficient mixing appliances in the sprayers mitigate but do not entirely overcome this difficulty.

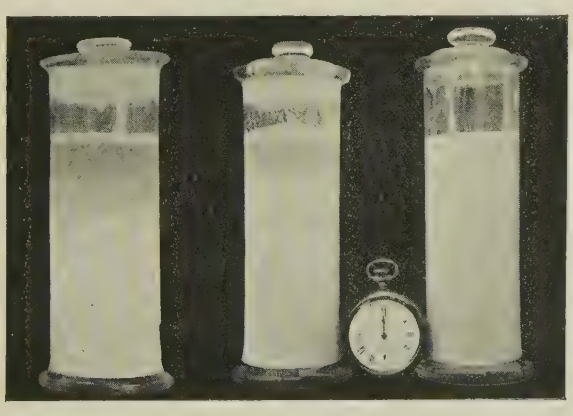
Until recently the paste form of precipitated arsenate of lead was the finest and best for use. When dried down to a powder it became coarse and incapable of fine suspension in water. The paste form is now, however, rapidly being supplanted by a very fine form of powder arsenate, manufactured by a special process. This form not only mixes readily with water, giving an extremely

fine suspension, but has special spreading properties which enable the poison to coat the entire surfaces of the leaves.

a b c

FIG. 33.—Rates of settlement of samples of arsenate of lead—after four seconds.

It has the added advantage of being cheaper to use, owing to the saving in freight and packing, than the paste which

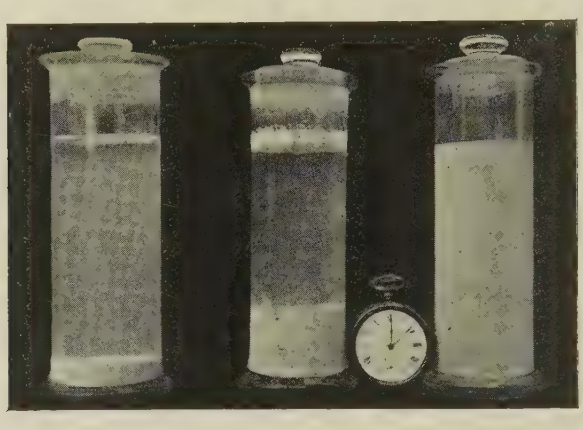


a b c

FIG. 34.—As Fig. 33, after lapse of one minute.

contains water to the extent of one-half of its total weight. For this reason the costs of pastes should be reckoned on

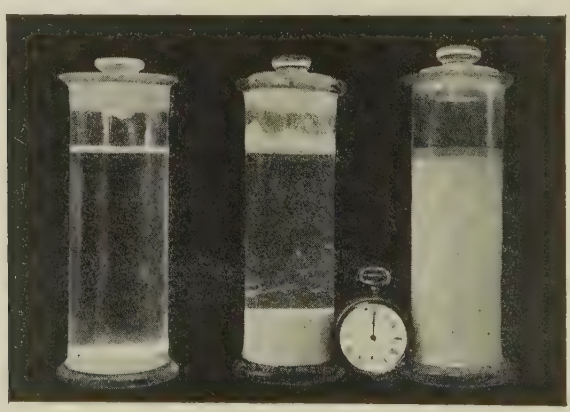
the percentage of water which they contain. Thus, a "fifty per cent. paste" needs to be at least half the cost of



a b c

FIG. 35.—As Fig. 33, after eight minutes' settlement.

powder, and even then is dearer in use than the powder, as shown above. It should be understood, however, that



a b c

FIG. 36.—As Fig. 33, after duration of twenty-four hours.

powdered arsenates are obtainable which are simply dried-down pastes, and are coarse and inferior in every way.

It is unwise to use soap of any kind with arsenate of lead. The special form of powder mentioned does not require it,

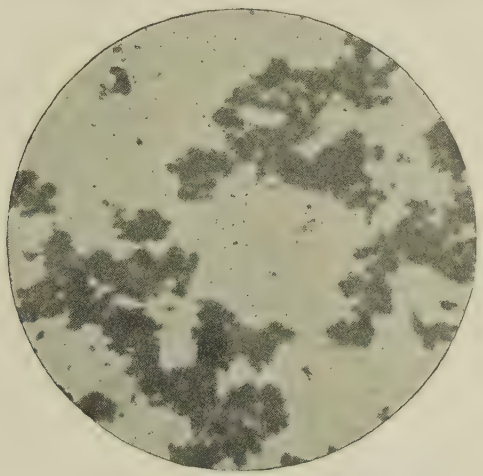


FIG. 37.—Brand (a) arsenate of lead seen under the microscope showing coarse aggregation of particles.

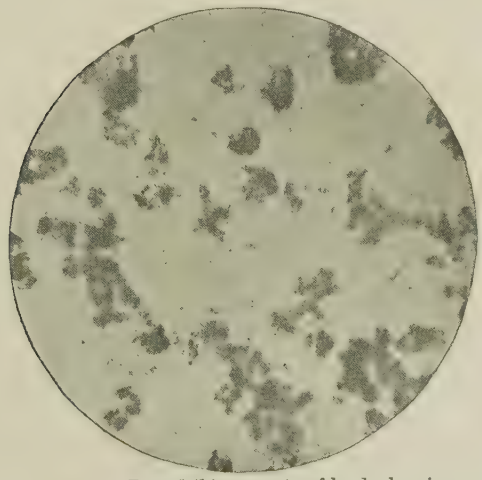


FIG. 38.—Brand (b) arsenate of lead, showing finer aggregation of particles.

and chemical action is always liable to take place, resulting in the production of arsenic in a soluble form which will cause damage to the foliage of the plant.

The illustrations show three commercial brands of arsenate of lead sold for spraying purposes. An equiva-

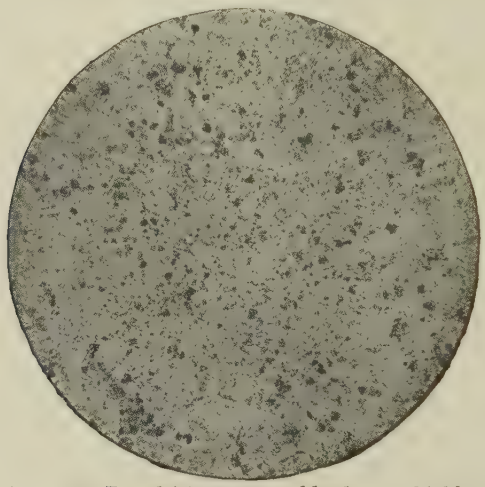


Fig. 39.—Brand (c) arsenate of lead, very highly magnified, showing the uniformly fine particles.

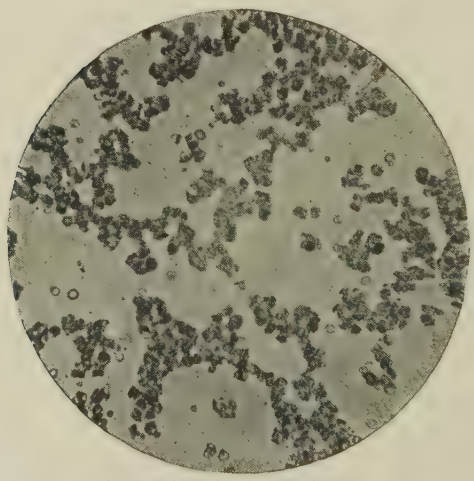


Fig. 40.—Corpuscles of human blood magnified to same extent as Fig. 39 for comparison.

lent quantity of each was placed in the three glass jars; water added; the stopper inserted; and all well and equally shaken. Photographs were then taken, which show

FIG. 41.—Showing effect of a too heavy spraying of arsenate of lead, causing the leaves to drip. Much of the arsenate runs off and is lost.

FIG. 42.—Showing the result of a coarse spray with coarse materials. The leaves are only very partially coated with arsenate.

the relative degree of settling or subsidence after (1) four seconds, Fig. 33 ; (2) one minute, Fig. 34 ; (3) eight minutes, Fig. 35 ; and (4) after twenty-four hours, Fig. 36. It will be noted how immensely superior for spraying purposes is the brand marked (*c*) in the figures.

This is confirmed by an examination of the particles in the three mixtures under the microscope. Fig. 37 shows

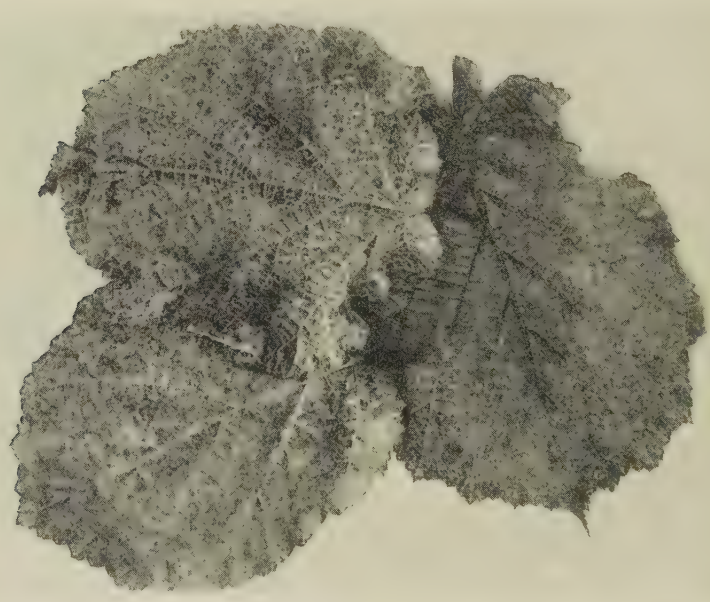


Fig. 43.—Efficient spraying with arsenate of lead, a fine spray with fine materials. Leaf surface practically covered with poison.

the relatively coarse aggregation of the particles of arsenate on examination of a single drop of the liquid in the jar marked (*a*) in Fig. 33. Fig. 38 is a comparative view of brand (*b*) showing a much finer condition, while in Fig. 39 the liquid (*c*) is much more highly magnified, but the particles are still seen as relatively fine. The high degree of magnification can be realised on comparing with Fig. 40, which shows the minute corpuscles of human blood magnified to exactly the same degree.

Method of Spraying.

As regards the method of spraying arsenate of lead, the diluted wash should be applied with plenty of force on the pump, but with a very fine nozzle, producing a close approximation to a "fog," so that the spray forms a fine coating on the surfaces of the leaves, but does not run or even drip off. On examination of the leaves after spraying and allowing time to dry, the arsenate should be seen as a fine uniform coating over the entire surface of the plant or tree.

Precautions.

Reasonable care should be used in handling any compounds of arsenic, as they are all highly poisonous. If stock are feeding in the orchards, they must be excluded during the spraying and for several days after. Carelessness in this matter has given rise to many cases of poisoning in the past. As previously stated, it is, of course, perfectly safe to use a Derris wash, and the animals need not be excluded from the orchard even during the spraying itself, as it is quite non-poisonous to stock of any kind. Additional description of leaf-eating pests will be found in Chapter XV.

Figs. 41–43 show the results of spraying in the manner previously described and are self explanatory. A result equal to Fig. 43 is quite capable of achievement in practice, and should always be aimed at.

CHAPTER VII

HIDDEN ENEMIES

In previous chapters the question of the destruction of insect pests which feed openly upon the leaves, either by eating the tissues of the plant or sucking the sap, has been considered. In all the cases described, the insect is at some period of its life-history accessible to a spray fluid, even if the time during which it is open to such treatment be comparatively short. In addition to these, the grower has to contend with certain pests which are practically at no time in their history amenable to spraying, and the destruction or control of such hidden enemies has long been a problem which has baffled the skill and ingenuity of investigators in this field of research.

It might appear at first sight that these pests are strictly outside the range of the subject of "Spraying Efficiency." In the opinion of the writer, however, it is of the greatest importance to know, not only when and how to spray, but "when not to spray," and in the case of the pests under present consideration, spraying would appear to be next to useless. To adopt the "practical classification" suggested by the writer in a previous article, these hidden pests comprise :

(1) Insects feeding inside the flower or young fruit.
(2) "Leaf miners," or insects living within the tissues of the leaves.
(3) Subterranean enemies, comprising insects eating the roots or sucking its juices, and those living within the root itself.

It is with the first of these divisions that the present article is concerned. The leaf miners are not, as a rule, serious pests, and the question of insects in the soil is a large subject, which will be considered in later chapter.

Apple Blossom Weevil.

The most serious of these hidden pests which, so far as our present knowledge goes, it is not possible to control by means of spraying is the **apple blossom weevil** (*Anthonomus pomorum*). On this matter one must entirely dissent with the statements which have been made from time to time to the effect that since a proportion of the fruit must, in any case, be " thinned out," this pest is not one that need be seriously considered. The same, if it were true, would hold good of many other pests, in fact, of all pests which destroy the blossom or fruit. The fallacy of such a view readily appears when it is admitted, as admitted it must be, that we have no means of controlling the depredations of any insect within definite limits, which will leave exactly that proportion of fruit to come to maturity which is most suitable to the particular tree concerned. The writer has recently seen instances of whole orchards in which scarcely a single bloom was left unattacked by the weevil. In a great many other cases a high percentage of blooms are " capped " as a result of weevil injury, which in a poor year means an exactly corresponding loss of crop.

Despite the voluminous literature on this subject, it may be of advantage, before considering the question of remedies, to refer briefly to the known life-history of this pest.

Life-history.

The adult weevils, male and female, hibernate during the winter under any shelter they can find, either on the bark or near by on the ground. At about the end of March or the beginning of April, depending upon the weather, they migrate to the tops of the trees, probably flying in most cases. Here, according to the recent investigations of *Schulz*,[1] they feed upon the buds until ready to pair, after which the eggs are deposited within the buds, one egg per blossom. Each female lays from twenty to fifty eggs. Hatching takes place in from eight to ten

[1] " Entom. Blätter," Berlin, XVI. 1920.

days, and the young grubs feed first upon the pollen cells and then attack the bud leaves or petals, the injury to these preventing the opening of the bud. In this way a shelter is provided during the whole period of development. In three weeks' time the grub pupates, and about a week later the mature weevil is produced, and eats its way out of the blossom, which is now dead, having a characteristic brown "cap" where the opened flower should have

Fig. 44.—Apple-blossom weevil damage showing "capped" blossom.

appeared (see Figs. 44 and 45). The weevil lives on the leaves during the summer, but the extent to which it feeds upon them is doubtful.

It appears to be without question that the grub requires shelter for its development, and if unusually warm weather causes the opening of the buds before the egg hatches, or, if hatched before the petals are injured, death follows as a usual consequence.

Control of the Pest.

Coming now to the question of possible remedies, it would seem in the first place an excellent practice to place bands

of sticky composition around the trunks of the trees. In many cases the bands are already on the trees, but it is essential to see that they are in an efficient condition. There is no doubt that many of the weevils do ascend the trunk in preference to flying.[1]

Spraying the unopened blooms with arsenate of lead has not in the past been found of much value, but, in view of the work of *Schulz* (previously referred to), it would appear well worth while to make systematic trials. In this con-

FIG. 45.—"Cap" of blossom removed to show pupa of weevil within.

nection it must be remembered that rapid growth occurs during this time, and in a few hours after spraying, fresh portions of the buds will be appearing. It follows that since the weevil is comparatively small and not a voracious eater, the possible effects of the spraying may be very transient.

Destroying the Capped Blossoms.

Many authorities have recommended the collection of the withered blooms containing the grub or pupa, by

[1] Especially in dull weather.

holding tarred boards or cloths beneath the tree, and jarring the trunk or branches. Where this is feasible it is certainly a very excellent plan, and if done at the correct time will result in a wholesale destruction of the pest. Unfortunately in large plantations containing full-grown trees this is not considered practicable by most growers.

Liming and Lime Sulphur Applications.

Applying a thick coating of lime, as is often done at the present time, as a preventative against aphis and psylla, may have a beneficial effect if the appropriate moment for the application happens to be chosen. Owing to the different stages of development of trees in orchards with mixed varieties of apples, and to the rapid growth of the buds, there must always be a large element of chance in such applications.

A late application of lime sulphur at winter strength has been found effective by several growers who are willing to take the risk of injury to the blossoms involved in such a treatment. Probably the buds are by this means rendered distasteful to the female weevil, but the practice is fraught with grave risk, and certainly cannot be recommended.

A New Treatment.

A method which has been found satisfactory in Germany is to thoroughly spray the tree trunks with thick lime wash in February, and then to dress the ground beneath the branches and up to the trunk of each tree with about half a barrow-load of gallnut meal, which is a waste product from tanneries. This material has a strong odour, and contains percentages of tannin, and is said to effectively prevent any weevil from reaching the trunks of the trees. Moss and weeds are also destroyed. The writer has made inquiries, and finds that gallnuts are apparently not used to any considerable extent in this country, but a similar "tanning-bark" waste is available at a few pounds per ton from tanneries, which quite probably would have a similar effect.

Apple Sawfly.

Another pest which is a great nuisance to fruit growers and is effectively entrenched against spraying operations is the Apple Sawfly. The winged female sawfly lays its eggs in the blossom on sunny spring mornings, and in one to two weeks the young maggots hatch out and bore into the side of the fruitlet, eating out large cavities in the interior (see Fig. 46*b*). Maggots often leave an attacked fruitlet and enter others before they become mature. When this stage arrives, they fall to the ground, if the fruit has not already fallen, and, penetrating a few inches into the soil, pass the winter in this condition. In the early spring the maggot pupates, and the mature insect leaves the ground two to three weeks after.

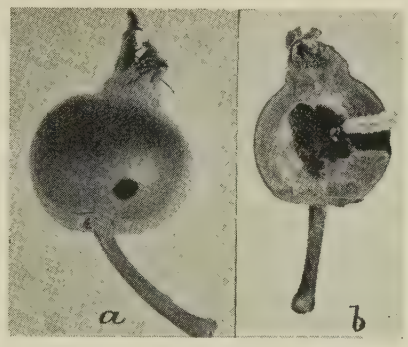


Fig. 46.—Apple Sawfly. (a) External view of infested fruitlet, (b) the same, cut open to show maggot and injury.

Since poison sprays are useless to control this pest, it is obvious that once a fruitlet is attacked, it is useless to try and save it, but as such are readily seen owing to the prominent hole on the side of the fruit (see Fig. 46*a*) it pays to pick and destroy them, as the maggot is thus prevented from doing further damage.

Keeping poultry in the orchard is an excellent preventative, especially during the summer months, as many of the caterpillars are eaten as they fall, or scratched up by the fowls. No method of treatment has so far had a sufficient degree of success to be recommended.

Pear Midge.

The third serious pest of fruit coming under this head is the Pear Midge. This insect is the curse of many a pear

grower. The attacked pears can very easily be seen by their ABNORMAL SIZE, compared with the healthy fruitlets (Fig. 47, *a* and *b*). As with the sawfly the midges appear in spring and the female, after pairing, inserts her eggs by means of a long slender ovipositor in the flowers. As many as thirty may be laid, and more than one female may attack the same blossom. Either opened or unopened blooms may

FIG. 47.—Pear Midge: (a) and (b) healthy fruitlets. (c) Infested pear fruitlet of same age cut open, showing maggots. (d) External view of same, showing abnormal size of fruitlet.

be attacked. The appearance of the maggots in the fruitlet is as seen in Fig. 47*c*. By the middle of June most of the maggots are mature, and then leave the decaying fruit. They penetrate the soil to a depth of one to two inches and remain in the ground till the following spring, pupating in the autumn or winter. At no time is it possible to destroy this insect by spraying. Burning the surface soil, or baking it, may be practicable in small gardens, but is obviously impracticable in large plantations. Poultry kept in the

orchard help, as in the case of the previous pest (see above). Kainit and other soil dressings have given benefit. There are, however, only two certain measures at present known to stamp out this most troublesome and persistent pest :

1. To hand-pick the swollen fruitlets in early summer. This is not a difficult matter, and should be attempted whenever possible. All infested fruitlets should be burnt or buried with lime. Co-operation, is however, essential, as the midges can fly a considerable distance, and trees can thus be attacked from a neighbour's orchard.

2. When the pest is very bad, it pays to sacrifice the crop in a given year by spraying with a strong arsenical wash, such as Paris green, or with strong lime-sulphur. The blossom will thus be destroyed, and the midge starved out. As before, co-operation in this matter is essential, otherwise the sacrifice is next to useless.

CHAPTER VIII

THE QUESTION OF THE WATER SUPPLY

Probably all manufacturers of spraying fluids, whether in this country or abroad, have at some time or another received inexplicable complaints from growers regarding the inefficiency of the wash they are supplying. Careful inquiries are made, but without avail, and there appears to be nothing to account for the trouble. The ingredients used are the same as in previous years and the wash complies with all the usual chemical and physical tests applied to it. A trial is then made on a practical scale with complete success, and the problem appears quite insoluble until an analysis is made of the actual supply from which the grower making the complaint drew his water for diluting the wash. It then appears that water, which for several years previously had been quite satisfactory, now produces "curdling" of the wash, which, on the correct degree of dilution, separates out as a thick scum on the surface. In other cases it remains in suspension as a fine curd or precipitate, but in either form it is quite ineffective when sprayed on the insects. In many instances there is serious trouble with the pump, the curd adhering to the valves and interfering with their action. Even when this difficulty is overcome, there is a tendency for the spray pipes and rods to become gradually blocked up by the precipitate and finally refuse to function altogether.

The reason for the water acting in this manner is its increased "hardness," due possibly to a dry winter or an abnormally hot spring, or, in the case of ponds and pools, to diversion or withdrawal of part of the feed-water. Last year almost all sources of water supply were found to have become "harder," and trouble was experienced in

making up spraying solution. This, of course, was due to the very scanty rainfall of the previous year.

Hardness of Water.

The hardness of water is produced by various mineral salts in solution, mainly to the bicarbonates and sulphates of lime (calcium) and magnesia. When soap solutions, or washes containing soap, are added to water, the fatty constituent of the soap unites with the lime and magnesia, producing an insoluble curd. If the amount of such salts present is small, there is still sufficient soap present to " take up " or emulsify this curd, but as the hardness increases the amount of soluble soap remaining correspondingly diminishes, till a time comes when the insoluble curd is precipitated or thrown out of solution. At this point practically the whole of the soap is destroyed, being converted into insoluble compounds of lime and magnesia, which are just as useless for spraying purposes as for washing clothes. Since practically all natural water, except fresh rain water, contains a proportion of these mineral salts, there must always be some loss of soap, occasioned by diluting the wash for spraying purposes. Why, then, it may be asked, use soap at all ? The full reply to this has been given in a previous chapter (Chapter V., pages 45-51). It was there shown that water itself has little power of " wetting " either the leaf surface or the bodies of insects, and that such wetting was a necessary condition of the action of all contact insecticides applied in solution. It is true that there are other substances which exhibit this " wetting " or spreading action, some of which can be usefully employed when the only available source of water supply is abnormally hard—making the use of soap quite inadmissible—or to increase the wetting action of liquids, such as lime sulphur, which decompose soap. None of these other spreaders, however, are equal to soap in efficiency, even when used at strengths which are much too costly in actual practice.

Waters of different origin may be roughly classified in order of suitability for spraying purposes as after-mentioned It

should be borne in mind, however, that enormous variations are possible, dependent upon the weather conditions.

1. Rain Water or Melted Snow.

This is the most suitable water, as it contains practically no mineral matter at all. It would probably pay in many cases to have a reservoir constructed for the collection and storage of pure rain water for spraying purposes. The writer has often met growers who were under the impression that pond and ditch water came under this classification and must be very soft. It is true that ponds are originally largely formed by direct rainfalls, but the water has remained in contact with the surface soil and been augmented by water draining off the land. It therefore rightly comes under the heading of

2. Upland Surface Water.

Such water has had a minimum contact with the earth, and for this reason dissolved comparatively little mineral salts. The amount and character of the dissolved matter depends mainly upon the kind of soil over which the water has travelled. In chalky districts such water may be comparatively hard. The hardness is also dependent upon the degree of evaporation which has taken place, resulting in concentration of the mineral salts present.

3. Surface Water Derived from Cultivated Land.

River water comes mainly under this heading, as most rivers flow largely through, and receive accessions from, land under cultivation. The hardness of such waters is different in different parts of the country, depending upon local circumstances and fluctuating at different seasons of the year. In chalky districts the water tends to be very hard, but where chalk is not present in the soil to any extent, river water is usually comparatively soft, and is less liable to variation at a given season of the year than almost any other natural water except the first class.

4. Shallow Well Water.

No general statement as to hardness can be made as these waters are subject to enormous variations; *e.g.*, of 29 samples examined from the same kind of soil, the analyses gave 4·6 minimum hardness, and 152·4 maximum (parts of carbonate of lime per 100,000). It is unwise to use water from wells for spraying purposes unless a recent test has been made.

5. Deep Well Water.

Although subject to much less variation, water from deep wells is normally of considerable hardness and unsuitable for spraying. Exceptions to this are, however, known, and if such water is readily accessible a test should be made.

6. Sea and Brackish Waters.

Sea water is of course quite unsuitable for spraying, under any circumstances, as the proportion of common salt (sodium chloride) which it contains renders it injurious to plants. Lime and magnesia salts, especially the latter, are also present in large proportions. Thus an analysis of the water of the Irish Channel gave 520 parts per 100,000 of magnesium salts, and 137 parts of calcium sulphate. The amount of common salt present was 2644 parts per 100,000, or about $2\frac{2}{3}$ per cent. Pollution of streams and rivers, producing brackish water, is common in the fen country, and as the water for spraying fruit is generally taken from the dykes, which normally contain surface drainage, it is important before using same to see that no contamination with salt water has taken place.

It follows from the foregoing that it is of the greatest importance to select a suitable water for spraying, where this is at all possible. In order to do this, the best way is to have samples of available water analysed and choose the one which is softest, *i.e.*, has the smallest proportion of dissolved mineral salts. At least one manufacturer of

spray fluids is prepared to undertake free analyses for customers, and to advise as to the suitability of a given supply, giving directions as to quantities of wash required for efficiency. It is, however, a relatively simple matter for growers to do their own testing. All that is necessary is to make up a solution of the particular concentrated wash selected, in rain or distilled water, and add small amounts from a measure to a known bulk of water, shaking or stirring until a foam or lather appears on the surface, which remains permanent for at least 15 minutes. This is

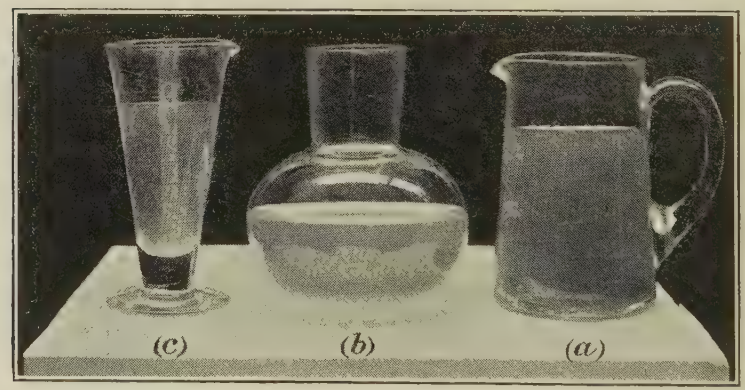


Fig. 48.—A simple method of testing the hardness of water or ascertaining the amount of a wash to employ to obtain maximum efficiency. All in readiness for test.

the minimum quantity of wash which will give efficient results with the water in question.

Practical Testing.

A convenient method of making the test which dispenses with the use of any but the simplest apparatus is as follows : Procure from any druggist a 4-oz. or 2-oz. photographic glass measure. This is marked in ounces and $\frac{1}{8}$ oz. (or drams). Make up a " 10 per cent." solution of the wash chosen for use, by measuring out 2 oz. and dissolving this with rain (or distilled) water in a pint jug, filling up to exactly 1 pint. This is the " test liquid." Now take a

bottle of the ordinary type used for toilet purposes, and measure into it 1 pint of the water supply available. (The bottle should be from half to two-thirds full.) Fill the measure up to the 4-oz. mark with the test liquid. All is now ready to make the test (see Fig. 48), which consists in adding small quantities, say about $\frac{1}{2}$ dram at a time, of the test liquid to the water and shaking well after each addition by placing the open palm of the hand over top of bottle. As soon as a lather or froth appears upon the surface of the liquid, which persists for at least 15 minutes, the test

FIG. 49.—The water with hardness partially "killed." The turbidity is due to the curd produced by the mineral salts present in the water, but there is no permanent "head of lather" on the surface yet.

is complete. Carefully read the amount of liquid left in the measure and substract from the 4 oz. (or 2 oz.) originally present. This gives the amount of test liquid employed for the water tested. Each dram used corresponds to $\frac{1}{2}$ pint of concentrated wash per 100 gallons of spraying solution (or if the measure is only marked in $\frac{1}{4}$ oz., each $\frac{1}{4}$ oz. is equal to 1 pint of wash). Thus, supposing that exactly $1\frac{1}{2}$ oz. of test liquid remained in a 4-oz. measure, the amount employed was $2\frac{1}{2}$ oz. (20 drams or 10 $\frac{1}{4}$-oz.), which corresponds to 10 pints, or $1\frac{1}{4}$ gallons, of concentrated wash per 100 gallons of spray solution. This is the minimum quantity necessary, and it is well to use an extra pint in addition to this in the actual spraying.

Explanation of Illustrations.

In the photographic reproductions, Fig. 48 shows all ready to make the test, (*a*) is the pint jug containing a

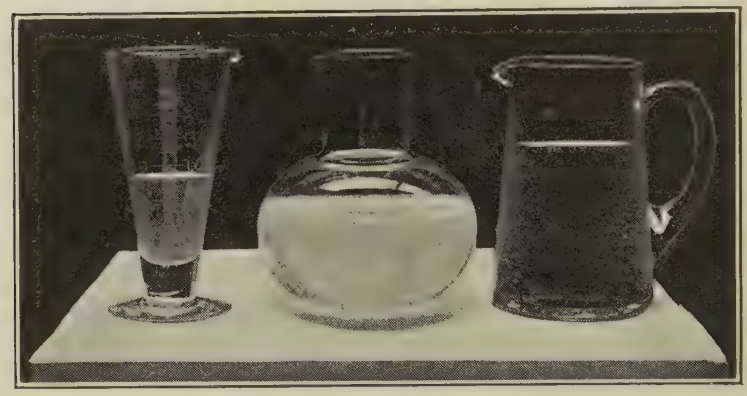


Fig. 50.—The hardness of the water just "killed," resulting in a permanent head of lather on the surface due to soap in solution. View after 15 minutes' standing.

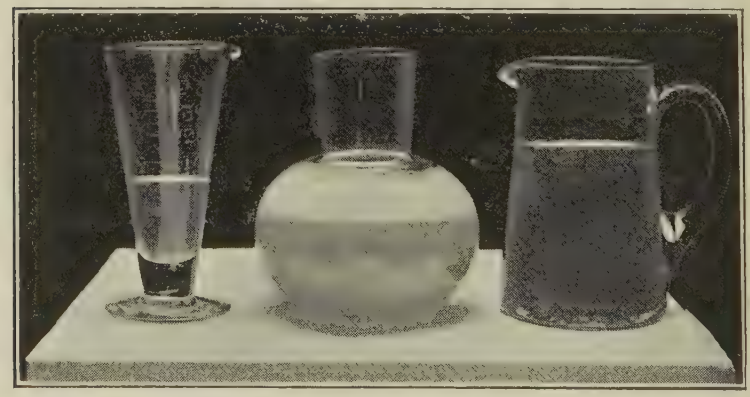


Fig. 51.—As in Fig. 50, but with slight addition (equivalent to 1 pint of wash per 100 gallons of water) of test fluid. Note fine head of lather. This is the exact condition for efficient spraying.

10 per cent. solution of the wash in use, (*b*) the bottle with 1 pint of the water to be tested, and (*c*) the photographic glass measure filled up to the 4-oz. mark with the liquid from (*a*).

In Fig. 49 is shown the water after partially killing the hardness with the test liquid, of which just 2 oz. has been used. No permanent lather yet appears on the surface.

When 20 drams or $2\frac{1}{2}$ oz. of the test liquid has been employed, as in Fig. 50, a lasting froth is obtained on shaking, which at the end of 15 minutes appears as shown. As each dram or $\frac{1}{8}$ oz. is equivalent to $\frac{1}{2}$ pint of the concentrated wash per 100 gallons, it follows that 10 pints or $1\frac{1}{4}$ gallons is the minimum quantity which can be used with this water to obtain proper covering of the leaf. It is,

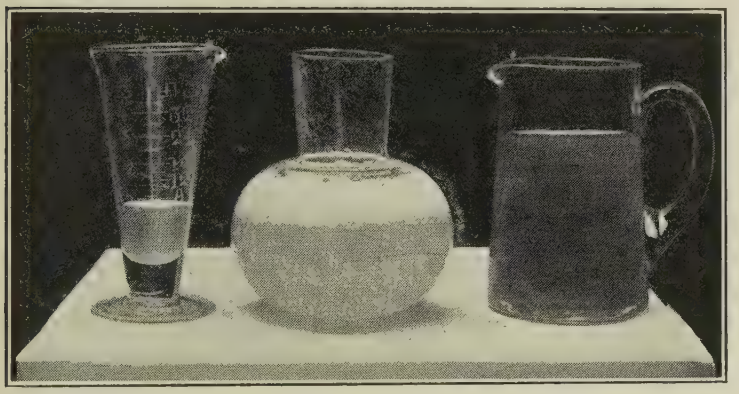


Fig. 52.—False head of lather produced when much magnesium salts are present in the water. It is due to the frothy curd, and disappears as more test fluid is added.

however, advisable in practice (as previously stated) to add a slight excess, say, 1 pint, making 11 pints altogether.

Fig. 51 shows the head of lather obtained on the surface after the addition of the extra pint. This is the appearance that a good soap wash should have when poured into the spraying machine.

Where the hardness is due chiefly to salts of magnesia, a kind of "false lather" is obtained on adding the test liquid, which is due to the action of the precipitated curd (see Fig. 52). On further addition of the test liquid this froth dies down and finally the permanent lather is obtained, as in Fig. 50.

Hardness is usually expressed in terms of the parts of carbonate of lime ($CaCO_3$) in 100,000 parts of the water. The older method was to state it in grains per gallon, called "degrees Clark." If a grower wishes to know roughly the hardness of his water in these terms, it is only necessary to use a soft soap of known strength, say, of "40 per cent. fatty acids." Any firm manufacturing soft soap will supply a small quantity of such soap of the correct strength. If a 10 per cent. solution of this is made up in rain or distilled water as shown previously (the soap being first dissolved in a little boiling water), and this is used as the "test liquid," then the approximate hardness of the water can be obtained by reference to the table given below :—

HARDNESS OF WATER.

"Drams" ($\frac{1}{8}$ oz.) of test liquid [1] used.	Parts of carbonate of lime per 100,000.	"Degrees Clark."
0	0	0
1	2·9	2·1
2 ($\frac{1}{4}$ oz.)	5·9	4·1
3	8·7	6·2
4 ($\frac{1}{2}$ oz.)	11·8	8·3
5	14·7	10·4
6 ($\frac{3}{4}$ oz.)	17·7	12·4
7	20·8	14·5
8 (1 oz.)	23·7	16·6
9	26·6	18·7
10 ($1\frac{1}{4}$ oz.)	29·6	20·8
11	32·5	22·9
12 ($1\frac{1}{2}$ oz.)	35·5	24·9
13	38·4	27·0
14 ($1\frac{3}{4}$ oz.)	41·4	29·0
15	44·4	31·1
16 (2 oz.)	47·3	33·2

If no permanent lather is obtained after the gradual addition of 2 oz. of the test liquid, a fresh trial should be

[1] 10 per cent. solution of soft soap of "40 per cent. fatty acid strength."

made, using this time only ½ pint of the water to be tested, and making up to the pint mark on the jug with distilled or fresh rain water. The corresponding figures given for the hardness in the table on previous page should then be doubled.

CHAPTER IX

THE CHEMISTRY OF SPRAYING

The chemist—using the term in its proper sense of a person skilled in chemistry and not in its frequent misuse as a drug salesman only—is a highly-trained specialist, and in discussing the various aspects of his science is accustomed to use a jargon of his own which is as Greek to all outside his own profession. To those who have to purchase and make use of various manufactured chemical substances in their business, however, a certain amount of elementary chemical knowledge is a very great asset. It enables them to procure the most efficient materials in the most economic manner, and to use them correctly, and prevents mistakes in handling or in mixing, which may, and often do, have serious consequences.

All agriculturists, whether growers of staple crops, fruit, hops, vegetables, flowers, or any other crops, and even those concerned mainly in the raising of stock, need to use in their business a great variety of manufactured chemical substances, the number and diversity of which increases every year.

While it is quite impossible in the limits of a book of this kind to do more than touch the fringe of a subject of this magnitude, it may nevertheless be of benefit in dispelling some common misconceptions to discuss very briefly and simply one or two of the main principles of chemical science, as applied to common substances, which are in daily use by growers of fruit and other crops.

Elements and Compounds.

The chemist distinguishes two classes of substances into which all materials may be divided, viz.: Chemical *elements* and chemical *compounds*, or mixtures of com-

pounds. The chemical elements consist of all the known metals and the non-metallic elements, of which the chief are oxygen, hydrogen, and nitrogen, which are gases; sulphur, carbon, silicon, phosphorus, and arsenic, which are solids, and a distinct group called the "halogens," consisting of chlorine, iodine, bromine, and fluorine. The total number of elements so far discovered is between 80 and 90, some of which are still of doubtful identity.

The essential character of these substances is that, no matter what means may be employed, it is not possible to split them up into other and simpler bodies.

A further point of great importance is that, apart from these known elements all other material substances consist either of chemical compounds or of mixtures of these, and such chemical compounds are produced by the uniting together of two or more of the elements before mentioned. This uniting together is called *chemical combination*, and is a phenomenon of the greatest interest and importance.

Not all the elements will so combine together, and some show a great readiness to combine with one or more particular element and little or no tendency to unite with others. This readiness to combine is termed "chemical affinity."

One more important point is that when chemical combination occurs, resulting in the formation of a new substance, the elements or the reacting substances always unite in certain definite proportions. In the illustration, Fig. 53, we see a small bottle (A) containing the metallic element, sodium, and a large flask (B) full of the non-metallic element, chlorine gas. When these definite quantities of the two combine together, the compound sodium chloride, or common salt (C), is produced, and the weight of salt produced is equal to the sum of the weights of the sodium and chlorine. If more sodium is used than just the proportion shown, it remains at the end unaltered, and similarly with the chlorine. In this case 23 parts by weight of the sodium combine with $35\frac{1}{2}$ parts by weight of chlorine, and produce $58\frac{1}{2}$ parts by weight of salt.

It will be noticed that the chemical compound, salt, or

sodium chloride, is entirely different in character from the elements sodium and chlorine. This salt is a white solid, easily dissolves in water, is quite harmless, and even a necessary article of diet. Sodium on the other hand is a soft metallic substance which has to be kept in paraffin oil, since it bursts into flame on contact with water (with which it forms caustic soda), while chlorine is a highly poisonous yellow gas, notorious as the first poison gas used by the Germans in the late war. Who could have

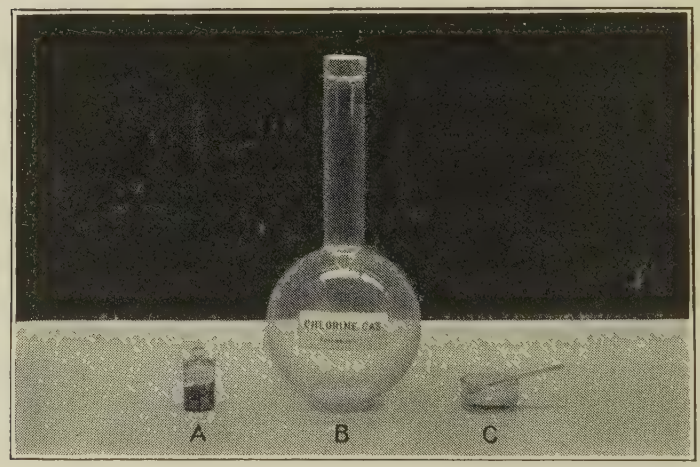


Fig. 53.—Illustration of chemical combination. 23 parts by weight of the metal sodium (A) combine with 35½ parts by weight of chlorine gas (B) and produce 58½ parts by weight of common table salt (C).

predicted that the combination of these two elements would produce harmless necessary table salt ?

Chemical Combination.

Take now the case of the reaction of two chemical *compounds* producing a new substance. Ordinary hard soap —household soap—is produced by the chemical combination of animal and vegetable fats with caustic soda. As soap is a definite chemical compound, it always contains the same proportion of soda in its composition (providing the same fat is employed, different fats varying the proportion

slightly). The difference between samples of soaps of different makes is therefore not due to variations in the percentage of soda present in combination with the fat, but to soda existing uncombined as an impurity, and to the amount of water present. If the fat were merely mixed with the caustic soda, the result is not soap, but a greasy mixture which separates on standing. In Fig. 54 is photographed the exact quantities of caustic soda (A), water (B), and fat (C), to produce the amount of soap shown (E).

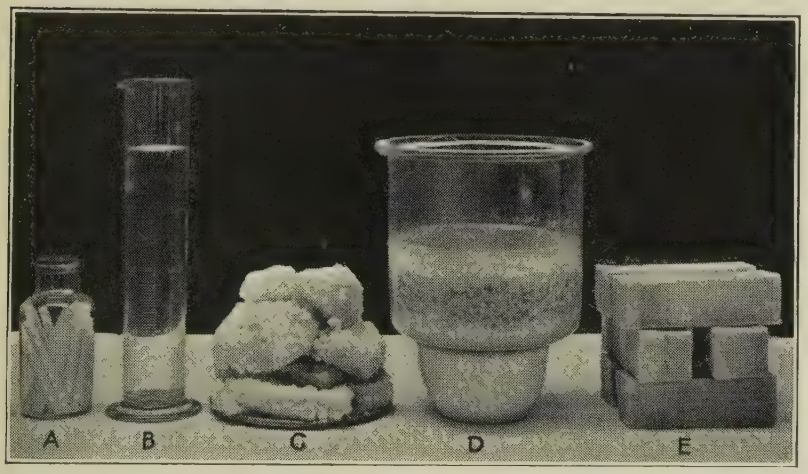


FIG. 54.—100 oz. of the chemical compound hard soap (E) produced by dissolving 9 oz. of caustic soda (A) in 28 oz. of water (B), and reacting chemically with 63 oz. of fat (C). On merely mixing without any chemical action taking place the result is as (D).

The large jar (D) shows what happens when the fat and alkali is merely mixed or shaken together. When chemical combination occurs we get an entirely different substance, not caustic on the skin or greasy, but on the contrary, a good grease and dirt remover or "detergent." Again who could have predicted this result of the chemical combination of fat and caustic soda ?

The exact weights of the substance shown were 9 oz. of caustic soda, 28 oz. of water (to dissolve the caustic), 63 oz. of fat (tallow in this case), making 100 oz. of finished

soap. If more of the caustic were used, it would remain "free" as an impurity, making the soap strong and harmful to the skin. If more of the fat, then the soap would be greasy, and not so good a cleanser; it would also tend to go rancid very quickly.

In Fig. 55 the curious result of using caustic potash instead of caustic soda is shown. Potash is almost identical

FIG. 55.—The production of 100 oz. of soft soap (E) by the chemical action of 8½ oz. of caustic potash (A) dissolved in 49½ oz. of water (B) with 42 oz. of oil (C). The result before combination occurs is shown in the bottle (D).

with soda in most respects, but it contains the element potassium instead of sodium. The result of the chemical reaction is now not hard soap, but transparent soft soap. In this case oil instead of fat has been used, but potash will combine with tallow in the same manner, producing a soft soap of similar character, but less transparent. The proportion of caustic potash required to combine with the oil or fat is higher than in the case of soda. The quantities shown in the photograph are 8½ oz. caustic potash (A),

49½ oz. water (B), 42 oz. oil (linseed in this case) (C), producing 100 oz. soap (E).

Fatty Acids.

Fig. 56 shows a further interesting and important fact about oils and fats and the resulting soaps. All vegetable and animal oils and fats without exception are chemical

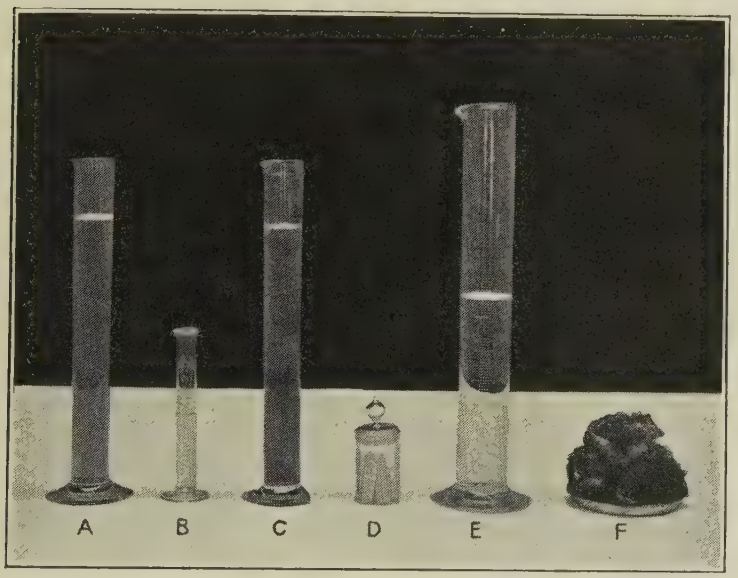


Fig. 56.—The splitting of oil into its component parts, viz., fatty acids and glycerine, before combination with the caustic potash. (A) 100 parts by weight of oil which yields (B) 10 parts by weight of glycerine and (C) 95 parts of fatty acids—water is taken up which accounts for extra weight. The fatty acids combine with 10 parts of caustic potash (D) dissolved in 125 parts of water (E) to produce 240 parts of soft soap (F).

compounds of *glycerine* with what are termed *fatty acids.* The fatty acids differ in the case of each oil and fat, but they are all similar in character (one of the simplest fatty acids is acetic acid, although this would not produce a soap in the usual sense of the term). The amount of glycerine yielded by all oils and fats is about 10 per cent. When the oil or fat combines chemically with the alkali, the glycerine is set free, and the fatty acid unites with the

caustic potash or soda. For this reason the strength of a soap is usually referred to in terms of the percentage of fatty acids in combination with the caustic alkali. Thus commercial soft soaps contain from 35 to 45 per cent. of fatty acids, according to the quality, and are made from all kinds of vegetable or fish oils. Hard soaps, unless these are adulterated with filling substances, such as silicates, starch, etc., contain from 50 to 70 per cent. of fatty acids, and toilet soaps over 80 per cent.

In the illustration (Fig. 56) is shown the oil (100 parts A), the fatty acids derived from it (95 parts C), the glycerine (10 parts B). The fatty acids combine with 20 parts of caustic potash (D) dissolved in 125 parts of water (E), and produce 240 parts of soft soap of 40 per cent. fatty acid strength (F). (The reader will notice that the weight of the glycerine on addition to that of the fatty acids is more than the original weight of the oil; this is because water has been taken up in the splitting of the oil.)

Arsenates and Arsenites.

One of the essential conditions to life on the earth as we know it, is the presence of the element oxygen in the atmosphere, and oxygen owes its value to its great combining activity. It enters into combination with all the metals, and most of the non-metallic elements, forming oxides. Thus iron on exposure to air soon gets coated with rust or iron oxide. Carbon forms with oxygen the gases carbon monoxide and carbon dioxide or carbonic-acid gas, and this again combines with the metallic oxides, producing carbonates, such as calcium carbonate or chalk, sodium carbonate, or ordinary washing soda. Arsenic unites with oxygen forming various arsenic oxides, and these combine with metallic oxides producing arsenates and arsenites. Arsenites differ from arsenates in containing less oxygen. Many of the arsenates are insoluble in water, such as lead arsenate, calcium arsenate, etc., and as long as these remain in the insoluble condition they are harmless to the leaves and tissues of plants. In the presence of soluble sodium or potassium compounds, such

as caustic alkali or carbonate of soda or potash, or even of soap solutions, certain amounts of soluble sodium or potassium arsenates are produced, which have a pronounced scorching action, and in fact will make good weed-killers. The strength of arsenates is best denoted by the percentage of arsenic oxide in combination. Thus a 15 per cent. arsenate of lead paste means that there is this proportion of arsenic pentoxide in combination with the oxide of lead in 100 parts by weight of arsenate paste.

Sulphur and Its Compounds.

Just as oxygen combines with other elements to form oxides, so sulphur unites with metals to form sulphides. The term polysulphides applied to solutions of lime sulphur means compounds of lime (calcium) and sulphur, which contain large proportions of sulphur. As sulphur compounds are powerful fungicides, it is probable that the higher the proportion of sulphur which is present in polysulphides, and the greater the percentage of these present in lime-sulphur, the more valuable it becomes as a spray for fungus diseases. As an increased amount of sulphur in combination in lime-sulphur raises the weight of a given volume of the solution, it is usually sold on its specific gravity or its relative weight compared with the weight of an equal measure of water. (Thus lime-sulphur of specific gravity 1·3 means that a gallon, say, of the lime-sulphur weighs 13 lb., as against 10 lb. for a gallon of water.) Since, however, lime-sulphur can be made to have a high specific gravity without a correspondingly high percentage of sulphur in combination, it is advisable always to purchase brands of known efficiency from reputable manufacturers.

Derris and Nicotine.

Derris is very remarkable in being non-poisonous to human beings and warm-blooded animals, while at the same time exceedingly toxic to insects of all kinds. Nicotine, on the other hand, belongs to the class of substances termed *alkaloids*, which are compounds of nitrogen, and all most

violent poisons. It is a narcotic poison, acting by depressing the heart. It thus needs handling with extreme care, and in cases of poisoning, emetics should be given, followed by strong coffee. The subcutaneous injection of carefully regulated doses of strychnine has proved useful, but must of course be performed only by a qualified medical practitioner. Since even the fumes of nicotine are poisonous, it must be kept tightly secured, preferably in sealed metal containers. Small quantities should be kept under lock and key. As an instance of the poisonous nature of the aklaloid, it is stated that one drop placed upon the tongue of a dog causes its death in a few minutes.

CHAPTER X

SUBTERRANEAN PESTS

One of the greatest problems in the science of warfare against insect enemies is how to deal successfully with attacks which take place on the hidden parts of the plant beneath the surface of the soil. These insidious enemies, being invisible, often remain unsuspected, the damage which they do being attributed to altogether different causes. It is obvious that methods which can be employed successfully against aerial pests are quite unsuitable for use on insects living below the surface of the ground. Thus any method of spraying could only be effective if the soil were entirely removed from the roots, which is, of course, quite impracticable. It might be thought that soaking the ground around the tree or plant with an insecticidal solution would prove effective, but it has been shown in practice to ensure penetration of the soil to any considerable depth, the application of very large quantities of liquid is necessary, and since such solutions are retained very tenaciously by the soil particles, they would be likely in many cases to have an injurious effect upon the plant itself.

Powder and Liquid Poisons.

There remain two methods, both of which have been employed with a considerable degree of success. The first of these is the use of powders which may be mixed with the soil, and which either emit poisonous vapours, or are slowly dissolved by the moisture in the soil and by showers of rain, forming a poisonous liquid which permeates to the roots. The other method is the injection of certain volatile liquids, which gradually evaporate in the soil, producing poisonous vapours. As regards the

pests themselves, it is necessary to distinguish between insects that live and develop within the root itself, and those that attack the root from the exterior, and are therefore true soil pests. In the former case little can be done to cure the attacked plant, and it appears only possible at present to ensure that neighbouring plants are protected from infection.

The Eelworm.

The most common pest of this description is the parasite known as the eelworm. This is a true worm, and is therefore strictly not an insect pest, but is for convenience always dealt with in the same connection. Eelworms are comparatively minute and vary from about one-tenth to one-thirtieth of an inch in length. They appear to the naked eye as minute twisted threads, creamy-white in colour and exhibit twisting movements of the body. They breed inside the root tissue by means of minute oval white eggs, and occur in very large numbers. Many varieties of plants are subject to attack, but, amongst fruit, strawberries are the chief sufferers. No marked symptoms of the attack appear, but the plants gradually fail, and finally wither. When an attack is suspected, one of the small rootlets should be broken open and the interior examined with a hand magnifier, when the " worms " are easily recognised. As previously stated, no cure is known for plants so attacked, but as on the death of the plant they enter the soil and by means of the characteristic twisting movements of the body reach healthy roots, it is best in all cases of attack to destroy the crop by burning. The ground should then be treated with one of the powder forms of insecticides cited below.

Other Ground Pests.

The number of insects which are pests upon fruit, and which live in the soil during some period of their life history, is comparatively large. Many of these, however, are not true soil pests, since although they inhabit the soil at

certain periods, they do not normally attack the roots. Two of the most destructive of root pests, viz. the wire-worm and the leather jacket, are not commonly found doing much injury to fruit, and will not therefore be considered as fruit pests. The caterpillar of the swift moth, and many grub of various beetles and weevils are common pests, and, in the case of small fruit, often do a large amount of damage. Certain ground beetles have also been described from time to time as injuring crops, especially strawberries. These are also liable to infestation by the curious familiar creatures known as "millipedes."

Fig. 57.—Woolly aphis attack on root of apple tree.

The most serious pest, however, with which the grower has to contend, is the ground form of the **woolly aphis** (Figs. 57-59). It has long been known that this insect lives both above and below ground, and that, therefore, spraying and destroying the colonies on the branches will not rid the tree of the attack, unless those underground are also destroyed. There appears in fact in many cases to be a constant migration between the roots and the branches. The effect

of the attack on the roots is the production of galls and swellings, and young trees frequently succumb to the combined attack above and below ground. Although most growers of fruit are very familiar with the characteristic woolly appearance of the aphis on the branches, it is not commonly realised that the roots of the tree are also being attacked by the same pest, and that this form is probably doing much greater injury.

As regards remedial measures, it is very important in

Fig. 58.—Woolly aphis, showing masses of wool (magnified).

the first place to see that young stock, before being planted, is fumigated with hydrocyanic gas. It is not sufficient to see that the roots and branches are free from the aphis itself, since eggs may be present which on planting will hatch and give rise to an attack.

Use of Carbon Bisulphide.

The use of powder forms of soil insecticides has not been found satisfactory, and recourse must therefore be had to

the injection of volatile liquids, which give off poisonous vapours. The one most commonly employed is carbon bisulphide, a liquid with an unpleasant pungent odour, the usual commercial article having a smell of decaying cabbage. Great care should be taken in handling this material, as, in addition to the vapour being injurious, the liquid is *extremely inflammable*. Experiments are now

Fig. 59.—Young apple tree attacked by woolly aphis.

being made with other liquids, *e.g.* with tetrachlorethane, which, however, would be more expensive in use. The instrument used for the injection is shown on Fig. 60. It is designed to deliver a small quantity of the liquid each time the plunger is forced downwards, and the charge is squirted out of a hole a few inches above the pointed nozzle of the instrument. The moveable foot-rest is adjusted to rest on the surface of the ground when the nozzle has been

forced in to the depth of from 6-8 in., and four or five injections are made at equal distances apart at about 2-2½ ft. from the trunk. If on forcing the nozzle into the soil the point is felt to come in contact with the root, a slightly different position should be chosen, as the roots themselves should not be wet with the liquid, although the vapour is quite harmless. The volume required for injection varies according to the size of the tree, from about 1 to 4 oz., and can be regulated by an adjusting screw. The most effective time to make the injection is after a spell of dry weather in late winter, March being the most suitable month. It is inadvisable to delay it after April. In addition to destroying the woolly aphis, the vapour will kill all other soil pests, except those which are in the pupal or chrysalis condition. (Figs. 61 and 62 show the ground injector in use).

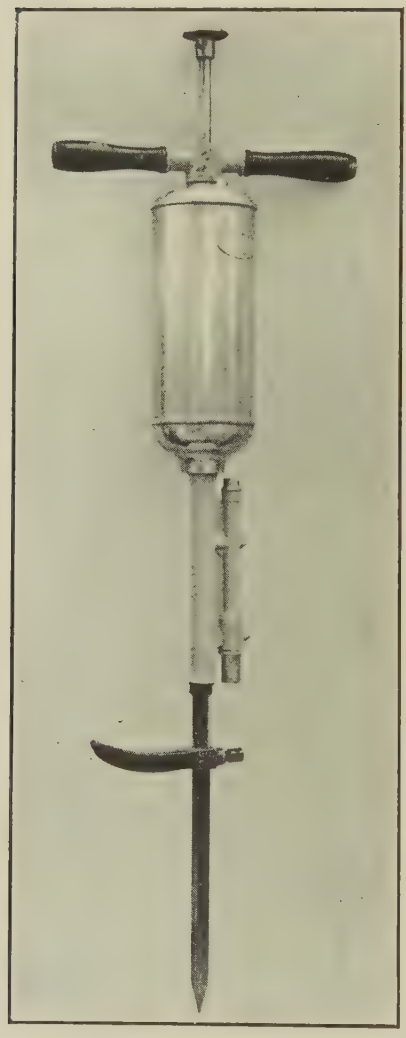


Fig. 60.—View of injector.

Powder Insecticides.

As regards the use of powder insecticides for other soil pests, the most suitable would undoubtedly appear to be

Derris in some form, as it is known to be extremely active upon all soil insects, and without harmful action to the nitrifying (useful) bacteria in the soil.

Fig. 61.—Operating the injector—note liquid issuing from side of nozzle.

The use of powerful antiseptic substances, such as certain coal tar acids, has proved to have an injurious effect upon the soil itself, destroying not only the harmful organisms,

but also the kind known as nitrifying bacteria, which are essential to plant growth, while their action on the insect pests of the soil is relatively weak.

Fig. 62.—Making the injections in positions indicated by pegs.

For surface application, the use of gas lime, soot and kainit (a mixture of crude sulphate and chloride of magnesia with sulphate of potash) is also common practice, and is also effective against slugs and snails; while kainit, besides acting as a weak insecticide, is also an excellent fertiliser.

A Pest of the Vine.

Fortunately, none of our British crops have soil pests which are comparable in the severity of their attack to the *Phylloxera*, which occurs as a veritable scourge on vines in France and many other countries. This insect is similar to the " woolly aphis," in that the attack takes place both above and below ground. In very many districts cultivation has been entirely suspended ; but, fortunately, resistant stocks are now obtainable, and these are increasingly employed. When the attack is discovered, it is usual to enforce very drastic means to prevent its spread. This consists in cutting off the stock about 4 in. above ground and burning same. The stump is now split down to the ground and drenched with tar, and each square yard of ground is treated with four injections of about $2\frac{1}{2}$-3 oz. each of carbon bisulphide, applied at intervals of three days. If thought necessary, the ground is further stamped down to ensure destruction of the stocks, and finally the stock is entirely dug up and removed with all its roots and burnt on the spot. Among the most successful methods which have been used in the past is complete flooding of the vineyards. The submergence must be total and prolonged to the extent of from 25-30 days, and is usually undertaken in September or October, at which time the vines are unaffected. The root lice appear to be completely drowned by submergence at this period, but whether such a method may be employed is, of course, entirely dependent upon natural conditions and situation.

Calcium Carbide.

It is interesting to note that experiments are being carried out with calcium carbide. This is mixed with dry soil or sand, and is buried in the ground below the level of the roots. It is slowly acted upon by the moisture, producing acetylene gas, which is said to be poisonous to some forms of insect life. This would appear to be a simple and convenient method of dealing with many root pests, but whether it can be economically employed would depend

upon the cost of the cheapest form of carbide available, as compared with that of carbon bisulphide and other insecticides, having regard to the relative effectiveness of each. Its powerful and extremely disagreeable odour would also probably prevent its extended use for this purpose.

CHAPTER XI

FUNGUS DISEASES

Despite the sweeping claims which are made in the advertisement columns of the trade press, it must be admitted that the science of combating fungus disease is still largely in its infancy. Great advances have doubtless been made, but the fact remains that to-day we do not possess a fungicide which can be termed really efficient in the sense that Derris or nicotine are efficient against insect pests. The difficulties are of course immensely greater. In the case of insects we are able to apply chemical agents, which, as, *e.g.*, in the case of nicotine are deadly narcotic poisons, or which, as with Derris, have a specific action on the nervous centres of insects. Both are without apparent action on plants, being themselves plant products, and can therefore be used without the slightest risk of injury to the plant tissues. With fungus diseases the case is very different. The fungus tissue itself is almost identical in character with that of the plant it attacks, and chemical agents which destroy the one are very apt to cause almost equal injury to the other. In the case of fungi which grow internally, hidden within the tissues of the plant, there is at present no known remedy, and the chance of finding one appears remote. Most of the parasitic fungi which attack plants, however, have a fruiting stage which takes place on the surface of the plant tissues, and it is only in the case of such external growths that we can hope to deal effectively with the disease.

In the treatment or prevention of fungus disease, advantage is taken of the following facts :—

1. In deciduous trees (those whose leaves fall in autumn) there is a resting or dormant stage during which the parts

of the tree above the ground are less susceptible to injury by chemical reagents than in the growing stage. At such times relatively strong solutions may be used against fungi without injury to the plant.

2. In fungi of which the growth is almost entirely on the *surface* of the plant (as in the "powdery mildews") the fungus tissues can be thoroughly wetted and permeated with the spray liquid, and if the reagent used is carefully adjusted in strength it may be insufficiently corrosive to injure the leaf tissues or other portions of the plant.

3. Since fungus infection is normally by spores carried in the atmosphere which alight on the leaves or other tissues and germinate on the surface, it has been found possible to prevent such germination by covering the leaves with a protective coating of relatively weak fungicidal material. The extremely delicate freshly germinated fungal tissue is thereby destroyed, while the outer skin (epidermis) of the leaf is sufficiently resistant to prevent injury to the plant.

4. Some of the worst fungus diseases are only capable of effecting an entrance to the plant through wounds or cuts, and if care is taken to protect severed branches and any exposed portions, infection is rendered much less likely.

5. Fungus diseases on fruit trees are usually more local than in the case of insect attacks, and a disease may often be kept in check by pruning off attacked boughs during the dormant season.

Just as in the case of high types of life, the health of plants has a great influence on their resistance to attacks of disease. Bright sunny weather causing vigorous growth is a great deterrent to fungus attack, as also is good cultivation resulting in healthy growing conditions.

The effect of fungus attacks on fruit trees may be considered as two-fold :—

1. Local.
2. Constitutional.

The local effects are partial or total destruction of leaves, shoots, or branches, and destruction, distortion, or dwarfing of the fruit, which is often disfigured with blotches or

scabs caused by the fungus or the dead skin resulting from its action.

The constitutional effects are seen in the gradual weakening of the plant, due to the absorption of the sap by the parasite. Growth is interfered with, and in the absence of successful treatment, the whole tree gradually dies. In other cases death is rapid.

FIG. 63.—Brown rot of apples, showing diseased and healthy apples. The latter specimen is becoming infected at the point of contact between the two.

Since by their very nature fungus diseases are highly infectious, it seems probable that they will never be adequately dealt with until it is possible to ensure united and simultaneous action over a large area. By such means only is it possible to prevent the production of fungus spores, which are carried long distances by the wind or

other agencies, and which are capable of producing the disease wherever they can germinate.

Fungicides.

The only substances at present known which appear to have any specific action on fungi—and these only to a very limited extent—are sulphur, certain chemical compounds of sulphur, and various copper salts. In the case of many powdery mildews, benefit is derived from distributing the sulphur—in the finest obtainable form—on to the plant. In other cases it is best to apply the sulphur in the form of various sulphides (compounds of sulphur with metals such as calcium, potassium, etc.). The most active sulphides are those in which the sulphur is present in high proportions—termed polysulphides. Many of these are water soluble, but great care must be taken to adjust the dilution so that the plant itself is not injured. Calcium (or "lime") polysulphide is the cheapest material to use, and is sold under the name of "lime-sulphur." It also contains varying amounts of thiosulphate, which is produced during the manufacture, and which is useless as a fungicide.

Lime-sulphur solutions may be used at relatively high concentrations for winter washing, but the wash should be applied as late in the dormant season as is consistent with absence of risk of injury to the buds, *e.g.*, see frontispiece; stage 1, 2, or even 3 in some cases (browning of the petals is not usually serious, providing the delicate stamens and pistil of the flower remains uninjured).

For spraying plants in leaf only dilute sulphides should be used, and in the case of lime-sulphur a great increase in efficiency results on adding a suitable spreader to the wash. This enables an efficient wetting of the fungus—so necessary in all spraying—and as soap is useless for this purpose, being destroyed by the lime, spreaders like casein and caseinate of lime may be used. Unfortunately these have certain grave disadvantages in use.[1] The caseinate is produced by the action of lime water on casein or milk curd (from skimmed milk).

[1] See page 118.

Copper is used in the form of the sulphate (bluestone) for winter spraying. For treatment of trees in leaf the

Fig. 64.—Bad example of apple canker. Cankered branch.

substance known as Bordeaux mixture, produced by the action of lime on bluestone, is employed. This is almost

insoluble, and when sprayed forms a protective coat on the surface of the leaf. Burgundy mixture is very similar in composition, and is made by the action of carbonate of soda in place of lime on bluestone.

Many fruit trees are very susceptible to the action of copper, which scorches the leaves and causes them to fall or injures the fruit. Apples are often roughened or russetted by "copper injury," and it is now more usual

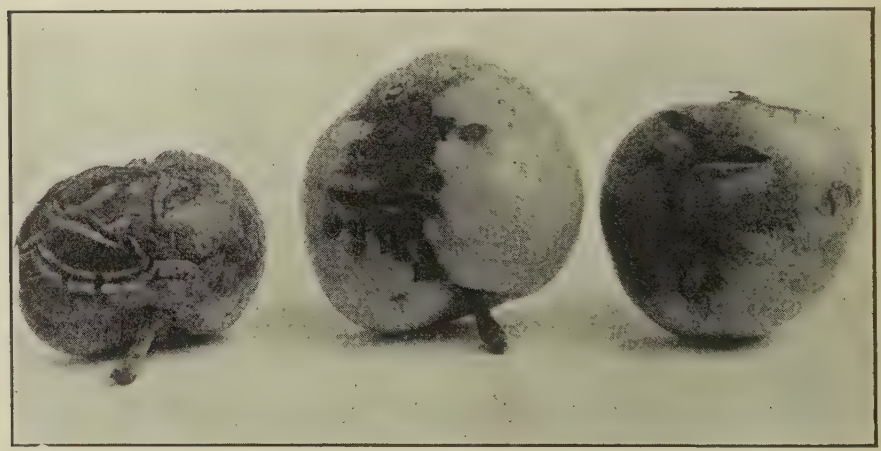


FIG. 65.—Apples badly affected with apple scab ("black spot") disease.

to substitute lime-sulphur for Bordeaux in spraying many varieties of fruit.

Bordeaux or Burgundy mixture is of course invaluable for potato blight, and is used regularly as a preventive of attack.

Some ready mixed manufactured fruit washes contain sulphur in combination with potash and soap, and have good fungicidal properties when used at the strengths recommended, besides being contact poisons for sucking insects. If such washes are used it is of advantage to keep the trees clean by the use of lime-sulphur as a winter wash, as in addition to its fungicidal action, lime-sulphur in strong solutions removes lichen and similar growths, and keeps the bark in a healthy condition.

Fungus Diseases of Fruit.

For descriptions the text-books [1] must be consulted. Treatment is briefly as follows —

Apple Scab (Black Spot). (See Fig. 65.)

Remove blistered shoots.

Spray with winter strength lime-sulphur or Bordeaux

Fig. 66.—Silver leaf disease on a Victoria plum, showing healthy and silvered leaves.

just before opening of leaf buds. (Stage 1, and sometimes 2, frontispiece.)

Spray with weak lime-sulphur or Bordeaux [2] just after fall of blossom. (Calyx stage, frontispiece.)

Spray four weeks later if signs of disease are seen.

Alternatively use a good fungicidal fruit wash on the latter dates.

[1] See the author's book, *Insect Pests and Fungus Diseases of Fruit*, Cambridge University Press.

[2] See, however, caution *re* liability of injury to many varieties of apples on previous page.

Apple Canker. (See Fig. 64.)

Cut out cankers and dress with tar; remove cankered branches.

Spray before leaf buds open with winter strength lime-sulphur.

Fig. 67.—Fruiting stage of the silver leaf disease on a dead branch of Victoria plum tree.

Apple Mildew.

Spray the fungus with a fungicidal fruit wash when seen, and the next year, as follows :—

1. With winter strength lime-sulphur at dormant stage (see frontispiece).

2. With summer strength lime-sulphur at calyx stage (see frontispiece).
3. A month later with same strength if necessary.

Brown Rot. (See Fig. 63.)

Remove and destroy diseased apples.
Spray with winter strength lime-sulphur before leaf buds open. (Dormant stage.)

Apple Blossom Wilt.

Remove and destroy cankered spurs and branches.
Spray with good fruit tree wash in early spring, or with lime-sulphur.

Cherry Leaf Curl.

Prune off and burn affected branches.
Spray with Bordeaux mixture, lime-sulphur, or good fungicidal fruit wash at time of opening of leaves. (Late dormant stage, see frontispiece.)

Cherry Leaf Scorch.

Remove all withered leaves in winter or early spring.
Spray with Bordeaux mixture, lime-sulphur, or fruit-tree wash (summer strength).

1. Just before blossoms open. (Pink stage, see frontispiece.)
2. Just after they have fallen. (Calyx stage, see frontispiece.)

Cherry Scab.

As for Apple Scab.

American Gooseberry Mildew.

Spray with summer strength lime-sulphur in early summer.

Peach Leaf Curl.

Cut away diseased shoots.

Spray with Bordeaux Mixture before buds begin to swell in spring.

Pear Scab.

As for Apple Scab.

Silver Leaf. (See Figs. 66 and 67.)

Cut off and destroy all branches which are dead or show silvered leaves to a point at which no brown stain appears in the wood, and coat all cut surfaces with Stockholm tar.

So far as the author is aware, no remedy of recognised efficiency is at present available.

CHAPTER XII

INSECTICIDES AND FUNGICIDES

I. For Sucking Insects

DERRIS

The active principle of Derris is without question the most powerful insecticide known. It is obtained from certain species of the Derris plant, which grows wild in the tropics. To the active insecticidal principle the name of "Derrid" has been given by one investigator. This active principle, when extracted from the plant, appears always to have the same insecticidal power, which is several times greater than that of pure nicotine. Derris, being itself a vegetable product, is quite harmless to the most delicate foliage.

Action on Insects.

Derris appears to act upon the nerve centres of insects, being absorbed by contact with the skin. It has also been found to kill leaf-eating insects by absorption through the digestive system. In this respect it is unique—constituting an all-round insecticide. Many growers have used the powdered Derris root (under the registered name of *Polvo*) as a caterpillar spray, with very efficient results. Against aphis, psylla, capsid, and other bugs, and sucking insects of all kinds, it is extremely deadly.

Action on Mammals.

Derris is, in moderate doses, quite non-poisonous to man, and apparently to all warm-blooded animals. In experiments recently undertaken, it was found that 1 part in 1000 of the body weight of the powdered root could be taken without ill effects by the animal in question.

Method of Use.

The use of Derris and its preparations as insecticides has been patented in Great Britain, U.S.A., and in most of the civilised countries of the world by McDougall & Yalding, of Kent, England. For several years past this firm and its predecessor has used Derris in its preparations, under the registered names of *Polvo* (powdered Derris root) and *Katakilla* (Derris root and powdered soap). It is now obtainable in liquid form as *Derrisine*, of an insecticidal strength about equal to that of pure nicotine.

Derris preparations should always be used with soap whenever possible (*Katakilla* contains the soap already mixed).

Strength of Spray.[1]

1. Polvo (Derris powder). To be used with sufficient soap to give a wetting solution.
   For all sucking insects use :—
   8–10 oz. of Polvo [1] to 60 gallons of soapy solution.
   (150–200 grammes to 100 litres.)
   Stir first with a small quantity of the liquid. Then mix into the bulk of the soapy solution.
2. Katakilla (Derris powder with soap).
   For all sucking insects use :—
   2–3 lbs.[1] to 60 gallons of water, according to hardness (see page 71).
   ($\frac{3}{4}$ to 1 kilogramme to 100 litres.)
   Mix the Katakilla first thoroughly with a small quantity of water in a bucket, then add to the bulk of water and stir well.
3. Derrisine (Derris in concentrated liquid form).
   For all sucking insects use :—
   5–7 fluid oz. of Derrisine to 100 gallons of soapy solution. This may conveniently be measured out in a photographic glass measure and stirred into the soap solution.
   (30–50 c.c. to 100 litres.)

[1] The manufacturers sell Polvo and Katakilla already packed in bags of the correct weight.

NICOTINE

Nicotine belongs to the class of chemical substances termed *alkaloids*, most of which are very active poisons obtained from plants. It occurs in all varieties of tobacco, varying from ½ to 7 or 8 per cent. Commercial nicotine is a yellowish to dark brown very pungent liquid. It must be handled with the greatest care, being one of the most poisonous substances known. The inhalation of the fumes is also very dangerous.

It is usually sold on a basis of 95 per cent. purity, and is liable to adulteration with water, and other bases such as ammonia and pyridine.

Crude nicotine sulphate, "40 per cent.," is a cheaper form of nicotine. It is a dark brown liquid, containing the nicotine in the form of sulphate of about 40 per cent. purity in terms of pure nicotine.

In this country nicotine, though still in considerable use, is being rapidly displaced by Derris for insecticidal purposes. Derris has the advantage of being quite safe to handle, while it is also more efficient and considerably cheaper in price. In America nicotine is still employed as an insecticide on a large scale, the stringent conditions imposed by the authorities rendering progress in spraying difficult.

Action on Mammals.

Nicotine is a violent poison to all mammals, and requires the utmost care in handling. Inhalation of the fumes is also very dangerous. It should be kept in tight (preferably metal) containers, in a locked building, and handled only by experienced and responsible persons.

Antidotes.

In cases of nicotine poisoning an emetic should be given as soon as possible, and when this has acted, stimulants should be taken. Strong coffee and camphor have proved useful. Medical aid should be summoned without delay.

The hypodermic injection of strychnine (by a skilled practitioner) has proved of value.

Strength of Spray.

1. For all sucking insects use from 6 to 12 oz. of nicotine to 100 gallons of soapy solution.
2. Nicotine sulphate (40 per cent.) requires to be used at 2½ times the above strength for the same results.

QUASSIA

Quassia is a relatively weak insecticide, It contains a bitter principle "Quassin" which is intensely bitter and can be isolated in crystalline form. It is obtained from the wood of the quassia tree, of which there are two varieties, Jamaica quassia (*Picræna excelsa*) and Surinam quassia (*Quassia amara*). It is usually sold in chips, which require boiling in hot water, or preferably in soap solution, to extract the quassin.

It has been stated to have the effect of rendering the leaves of plants distasteful to aphides, and so preventing further attacks, but there is insufficient evidence of this. It is questionable if quassia is ever a really efficient spray, having regard to its relatively feeble action in comparison with Derris and nicotine, and it is in consequence rapidly falling out of use.

The preparation of quassia wash by boiling the chips is very troublesome, and owing to the varying qualities of the commercial article, it is impossible to give any reliable directions for strength of wash.

PARAFFIN OIL

Paraffin oil and most other distillates of petroleum and coal tar are very destructive to insects as well as to plant life. When employed as emulsions they have considerable insecticidal action, but such emulsions are in practice so

liable to separate that their use is decidedly risky. They should therefore only be used when the trees are dormant during the winter. Employed at such times they are useful for destruction of certain scale insects.

Oil emulsions, in order to be safe and effective, should be made under scientific control. For this reason the author recommends growers not to attempt to prepare emulsions, but to purchase the standardised factory-made product.

For spraying on trees or plants in leaf, oil emulsions should in no circumstances be used.

LIME-SULPHUR

This is the name given to the somewhat complex liquid produced by boiling lime and sulphur with water. Its efficiency for spraying purposes appears to depend upon the amount of sulphur in solution, probably on the percentage of polysulphides present (see page 102). The factory-boiled lime-sulphur of 1·3 specific gravity is the best to employ where possible.

Lime-sulphur is valuable as a winter spray against scale insects and for cleansing the trunks and branches of trees. Its use as a fungicide is referred to later on page 118. As a summer spray its use is often somewhat risky, but it is effective against red spiders and mites on certain plants. Experience has abundantly shown that owing to the complexity of the different substances produced in boiling lime-sulphur, and the difficulty of controlling their formation, it is inadvisable under any circumstances to use a home-boiled mixture.

The factory-made article, prepared under scientific supervision, after careful testing of the purity of the raw materials, should always therefore be employed for spraying.

The chemical aspect of lime-sulphur solutions is referred to on page 87.

Strength of Spray.

1. Dormant trees (employing factory-boiled 1·3 sp. gr. lime-sulphur).

Dilute the lime-sulphur (1·3 sp. gr.) 1 in 20 with water (5 gallons–100 gallons).

2. Trees in leaf (only necessary for fungus attacks), see under various fungus diseases.

Dilute the lime-sulphur (1·3 sp. gr.) 1 in 100, or a little stronger if the tree will stand it. Several susceptible varieties are liable to damage even at this dilution.

CAUSTIC SODA

Caustic soda is used as a strong winter wash, either alone or emulsified with paraffin oil. It is useful, when taking over a very neglected orchard, to destroy lichenous growth on the trees. At other times lime-sulphur is preferable for this purpose, being equally effective, and having less burning action on the skin and clothes of the operators.

Strength of Spray.

20 to 25 lbs. of pure fresh caustic soda per 100 gallons of wash. Place the caustic soda in a wooden vessel, and add about 5 gallons of water. When dissolved, add the bulk of the water and stir well.

LIME

Lime has been used with advantage as a cover wash in early spring to prevent the hatching out of various insect eggs. This it appears to effect by its physical action in impeding the young larva as it struggles to emerge from the shell. It also probably protects the buds from attack by the apple blossom weevil. It should be applied as late as possible in the dormant season.

Strength of Spray.

Two cwt. of freshly-burnt quicklime per 100 gallons of wash. The lime should be slaked a few hours before using. After slaking about 30 gallons of water is added, and it is allowed to stand. When spraying, one pailful of this may be taken to two pailfuls of water.

II. Insecticides for Chewing (Leaf-eating) Insects.

(See Chapter VI.)

DERRIS

For description see page 109.

M'Indoo and others have shown that Derris acts both as a stomach poison and as a contact insecticide. Unless the combined preparation of Derris with soap (*Katakilla*) is used, it should be always employed with soap as a spreading agent. Where possible, and if employed without soap, the liquid form (*Derrisine*) should be used. A thorough wetting of the leaves is essential, and a fine day should be chosen for the spraying. It is also specially important to spray, if possible, when the caterpillars, "maggots," or other leaf-eating insects are young. All attacks of such pests are difficult to control when the larvae or young are maturing.

As previously mentioned, Derris has the great advantage of being non-poisonous, and can be used on cabbages and other vegetables, and on many kinds of fruit when near the ripening stage.

Strength of Spray.[1]

Polvo (*Derris powder*). To be used with sufficient soap to give a wetting solution.

For biting insects use :—

8–10 oz.[1] per 40 gallons of soapy solution.

(250–300 grammes to 100 litres.)

Stir the Polvo first with a small quantity of the soapy fluid, then mix into the bulk of the solution.

Katakilla (*Derris powder with soap*).

For biting insects use :—

2–3 lbs.[1] of powder to 40 gallons of water. More must be employed if the water is hard.

(1¾ kilogrammes per 100 litres.)

Mix the Katakilla first with a small quantity of water in a bucket, then stir into the bulk of water.

[1] The manufacturers supply Polvo and Katakilla in packages of the correct weight for dissolving.

Derrisine (*Derris in concentrated liquid form*).

For biting insects use :—

10–12 fluid oz. of Derrisine per 100 gallons of soapy solution.

(60–72 c.c. per 100 litres.)

This is conveniently measured out in a photographic glass measure, and stirred into the bulk of the soap solution.

ARSENATE OF LEAD

Arsenate of lead is the only arsenical compound which has met with general approval for its efficiency and absence of serious scorching or leaf injury. The use of Paris green and London purple has practically died out, except in a few localities. Calcium arsenate is still in the experimental stage, and reports on its efficiency and safety vary in a remarkable manner. It is certainly much too dangerous in action for general use.[1]

Arsenate of lead is a powerful poison if taken into the stomach. Reasonable care must therefore be exercised in its use. It can be prepared by the action of soluble salts of lead (such as the acetate) upon alkaline arsenates, but it is much safer for the grower to use the factory-made product. (See Chapter VI.) Arsenate of lead is valued, other things being equal, on its content of arsenic oxide (As_2O_5). The particles must be fine ; coarse arsenates are quite unsuitable for spraying.

Strength of Spray.

Powder Arsenate.

2–3 lbs. per 100 gallons of water.

(1 in 330 to 500 or 200–300 grammes per 100 litres.)

Paste Arsenate.

4–6 lbs. per 100 gallons of water.

(1 in 170 to 1 in 250 or 400–600 grammes per 100 gallons.)

[1] See also page 54.

Notes.

A good quality arsenate suitable for spraying will remain in suspension without appreciable settlement for a considerable time. The specially manufactured powder form mentioned on page 54 has extremely fine suspension properties, and is readily mixed. It has been found efficient at a dilution of 2 lbs. per 100 gallons of wash. It is inadvisable to use soap or a mixed soap wash with arsenate of lead, as scorching of the foliage may result.

PYRETHRUM

This substance is a powder produced from the flower heads of the plant, grown principally in Japan. The powder is used alone or in admixture with flowers of sulphur. It has been found useful as an insecticide for house flies, cockroaches, and crickets. It has, however, proved useless on a larger scale for insects attacking plants.

III. Spreaders.

SOAP

The use of soap has been fully discussed in previous chapters (see pages 84–85, 47, 48). It is by far the most efficient spreading or wetting agent. The amount necessary varies with the hardness of the water (see Chapter VIII.). Either hard or soft soap may be employed, but the latter is preferable.

CASEINATE OF LIME (CALCIUM CASEINATE)

This is produced by the interaction of lime and casein or milk curd. For spreading purposes about $\frac{1}{4}$ per cent. or $2\frac{1}{2}$ lbs. per 100 gallons of lime-sulphur or other spray fluid is usually required, although double this quantity is also advised. Casein and caseinates have been the subject of considerable experiment, and are recommended by some

authorities. They are, however, extremely difficult to dissolve, especially the calcium salt, and quickly ferment and decompose, when the spreading properties are completely lost. The author's experience of casein and caseinate of lime or other compound of casein does not warrant him recommending it to practical growers as a substitute for soap for spreading purposes.

IV. Fungicides.

(For general description see Chapter XI.)

LIME-SULPHUR

For description see page 113.

Lime-sulphur is a valuable fungicide, and should be used as described under the various diseases (Chapter XV.).

BORDEAUX MIXTURE

This is prepared as follows :—

Bluestone (sulphate of copper) .	8 lbs.
Quicklime (lumps) . . .	8 lbs.
Water	100 gallons.

Dissolve the bluestone in a wooden vat in about 20 gallons of the water. This is best done by wrapping in a piece of sacking and suspending under the surface of the water, allowing to remain overnight. In another vat the lime is slaked and then made up with the remainder of the water to 80 gallons. The copper solution is now slowly added to the lime, stirring well. Test for excess copper by adding a little of the solution to a solution of yellow prussiate of potash. If a chocolate brown colour is produced there is free copper present, and more lime must be added.

Use the mixture at once, straining through a wire gauze at the machine.

BURGUNDY MIXTURE

Copper sulphate . . .	10 lbs.
Washing soda crystals (carbonate of soda)	12½ lbs.
Water	100 gallons.

Prepare exactly as for Bordeaux Mixture.

Note.—Both Bordeaux and Burgundy mixtures are liable to cause scorching of the leaves and "russeting" of the fruit of many English varieties of apples, pears, etc., and, in consequence, should be used with great caution.

CHAPTER XIII

UP-TO-DATE SPRAYING

A DESCRIPTION of the recent attempt to spray fruit trees by aeroplane should perhaps form the commencement of this chapter, in view of its title. That experiment, although most useful and instructive, and within limits quite successful, is unlikely for obvious reasons to be followed as a standard practice by the practical grower of fruit. In some respects it doubtless offers great advantages, especially where large acreages are concerned, but the actual application of the spray is unlikely to be under sufficient control in our present knowledge of the science of aviation.

The fundamental principle in spraying is that the insecticide or fungicide employed must be brought into intimate contact with the body or tissue of the insect or fungus in question. One method of accomplishing this is by the use of solutions of the reagent used with a substance which will cause a wetting or spreading of the liquid over the exposed surfaces. In practice a hose pipe for the projection of the spray liquid would perhaps effect this, but only with an enormous wastage of material. The most economical and also by far the most efficient way of ensuring the wetting of all parts of a plant is by the use of a fine spray or thick mist. (See Fig. 72.) For securing the best results the degree of fineness of such spray should be to a considerable extent under the control of the operator. Liquids can be split up or "atomised" into a spray by being forced under considerable pressure through a nozzle of special design. The principle usually adopted is first to give the liquid a circular motion by means of a spiral channel cut in the jet, and then to force it through a disc with a fine opening in the centre. By regulating the size of the opening and the distance of the disc from the spiral member,

a fine misty spray may be produced or a coarser but more powerful spray, which will carry to a considerable distance.

FIG. 63.—Spraying fruit with a medium-power petrol machine.

The one essential of all spraying machines is that they shall be able to maintain a high pressure on the liquid, since both the fineness and the power of the spray are dependent upon this factor. For spraying fruit trees the

FIG. 69.—Spray gun in operation. Adjustment for fine misty spray.

FIG. 70.—Spray gun in operation. Coarse powerful spray of great length, reaching to the tops of trees.

nozzles are usually placed at the end of lances made of metal pipe or of bamboo cane, to which the hose pipe

Fig. 71.—Spraying high fruit trees, by use of long lance and a platform spraying machine.

from the machine is affixed (see Fig. 71). Adjustable nozzles are available, in which the character of the spray may be changed by altering the distance of the disc-opening

by hand. A greatly improved form now largely employed is that known as the "spray gun." In this appliance the character of the spray can be controlled by a single twist of the handle, or the liquid may be entirely cut off at will. The spray gun is shown in operation in Figs. 69 and 70.

In spraying arsenate of lead, Bordeaux mixture, and the

FIG. 72.—Photograph of an efficient misty spray.

summer application of lime-sulphur, the idea is to get an even coating of the leaf, and a very fine misty spray should be used, excess of spray, causing dripping, being carefully avoided (see Fig. 41, under arsenate of lead, page 59).

When using contact sprays for aphis and other sucking pests, with soap or other spreader, a relatively coarse and

more forcible spray is an advantage, providing that care is taken to thoroughly wet all parts of the plant. (This is not easy with a jet of liquid issuing from the nozzle, as the foliage nearest the operator is apt to form a screen against leaves which are behind. A constant change of position is

Fig. 73.—Syringe sprayer suitable for amateur use only.

therefore advisable.) The absolute necessity for the use of sufficient soap or other spreader to prevent the liquid running off like "water off a duck's back" is referred to

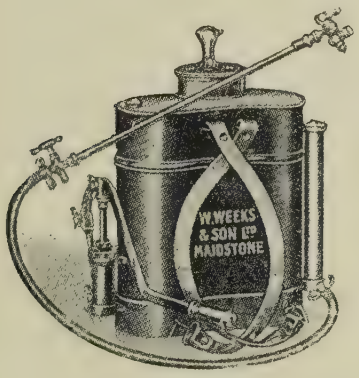


Fig. 74.—Knapsack sprayer. This is strapped on the back and is operated by a lever with one hand while the spray is directed with the other. Capacity about 3 gallons. Useful for small fruit and for experimental purposes.

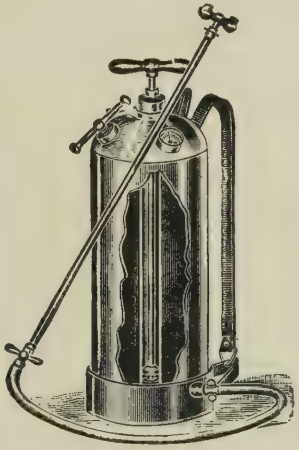


Fig. 75.—Automatic compressed air sprayer. An alternative to the knapsack type. Capacity about the same.

on page 47. For precautions to be observed in using poison sprays, see page 61. When corrosive liquids such as lime-sulphur or caustic alkali are being employed, the operator should be protected by suitable clothes and goggles or masks.

As nothing is more annoying than to have to hold up spraying owing to trouble with the machine, it is well to see that this is kept well protected and oiled and in efficient

working order. If trouble is experienced with the pumps, it is probable that insufficient soap is being used. Wooden tanks for the spray liquid are usually best, as they are acted upon least by corrosive liquids. An agitator should be placed in the feed tank of the sprayer for use with suspensions such as arsenate of lead.

Fig. 76.—Wheelbarrow sprayer. Suitable for small plantations. Capacity 12-50 gallons.

As regards the spraying machines themselves, there are many types of these suited to the size of the plantation and the character of the work. Illustrations are shown of typical spraying machines, of various sizes and designs, from the hand-syringe suitable for the small private garden to the large orchard power machine as used for commercial spraying.

The small petrol machines shown in Figs. 77 and 78 are relatively cheap, and are strongly advised for

Fig. 77.—A simple and inexpensive form of petrol power sprayer. 1½ H.P. engine.

small plantations in preference to the use of hand-operated machines involving expensive labour charges.

Sprayers of the knapsack (Fig. 74), and automatic type (Fig. 75) are very useful for experimental work and for

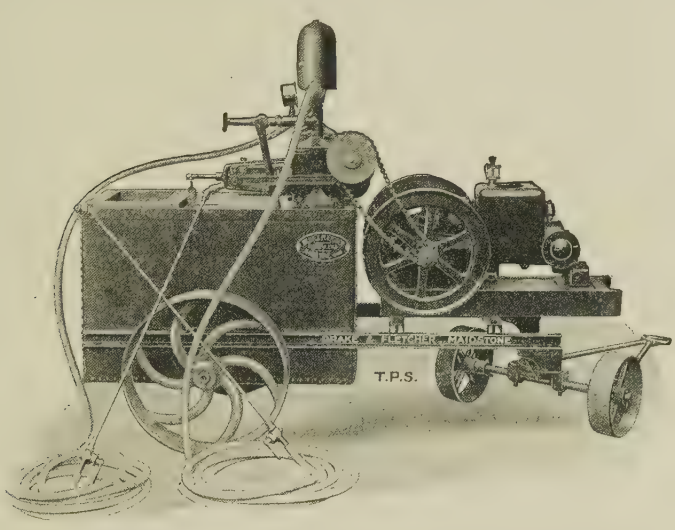


Fig. 78.—A useful machine for medium-sized plantations.

testing out new sprays and mixtures, the importance of which has been previously spoken of, and may here be

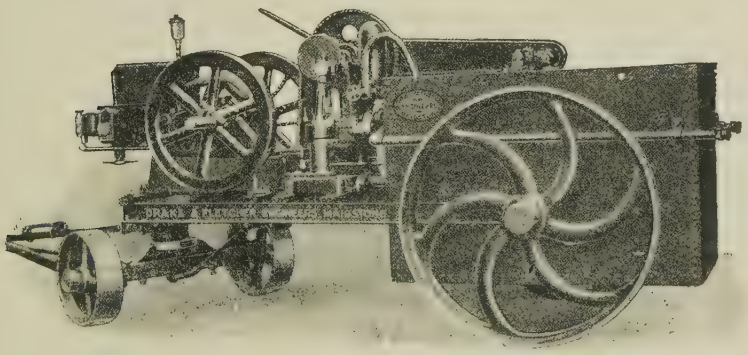


Fig. 79.—Type of 3 H.P. Sprayer with 2-throw high pressure ram pumps and 100-gallon steel tank. A useful type for all needs.

emphasised. In all spraying work it is very desirable to leave one or two untreated plants or trees as controls, in

order to compare at a later date so as to have a correct idea of the effect of the treatment.

Combined Sprays.

The use of a combined spray is often advantageous, since it halves the labour involved in making two or more applications. On the other hand, the full value of the materials is not always obtained when they are mixed together, and in many cases one or more of the substances is often destroyed by the mutual chemical action which occurs on mixing.

Lime-sulphur may be mixed with arsenate of lead, and the mixture will then be available as a stomach-insecticide for chewing insects and a fungicide for black spot disease, etc. It does not, however, follow that a suitable time for spraying for the one will also meet the case of the other.

Arsenate of lead may also be used with Bordeaux mixture without destructive chemical action taking place. Probably this mixture is the most generally suitable, since the sprays are often required at about the same period, and are applied to the trees in the same manner, *i.e.*, by means of a fine misty spray (see page 124). This practice is, however, more common in America than in this country, owing to the fact that many English varieties of fruit, especially of dessert apples, are very susceptible to what is termed "Bordeaux injury," which consists in a russeting and roughening of the skin of the fruit.

Soap, either soft or hard, and sprays containing soap, cannot be mixed with lime-sulphur, Bordeaux mixture, or other lime compounds, and it is inadvisable to mix soap solutions with arsenate of lead unless special precautions are taken, see page 87. In the case of other arsenic compounds, scorching is almost certain to occur if mixed with soap.

Derris, in order to be fully effective, should always be used where possible with soap, and the same remark applies to nicotine. If either of these are used with arsenate of lead, much larger quantities are necessary in order to produce efficiency, since adequate covering of the

leaf is not obtained. With the special form of arsenate referred to on page 54, however, an excellent cover is obtained. It should be borne in mind, that great circumspection must be used in the time when mixed sprays are applied, as each pest has its own particular period when it is most open to treatment, and spraying may be ineffective at any other time.

FIG. 80.—A powdering machine for use on fruit trees.

Dry Spraying.

Dry spraying is an alternative method of applying insecticidal and fungicidal material to a plant. It is by no means new, having been used many years ago in certain cases. Material applied in this form is not generally as effective as when sprayed in suspension or solution in water, since it is difficult to get the powder to adequately adhere to the leaves and other portions of the plant. Bordeaux mixture and arsenate of lead can both be applied in the form of powder, but it is best to choose the

time when there is a certain amount of dew on the leaves of the plant, which will cause adherence. The use of sulphur as a powder spray has been common for a great number of years, especially in the case of hops and for the treatment of powdery mildews.

Recently a further extension of the principle of dry spraying has been made, a spray being made to carry contact insecticides by the absorbent action of certain powders. These powder insecticides can be used against aphis and other sucking pests, as well as caterpillars, and although it is unlikely that they will replace wet spraying, they are certainly of use when water supplies are either unsuitable or difficult to obtain. A typical machine for projecting the powder is shown in fig. 80.

CHAPTER XIV

FUMIGATION

Insecticides in the form of poisonous gases or vapour are without question the most efficient in practice. They can be relied upon to destroy entirely every single insect pest upon a plant, since, unlike a wet spray, which kills where it penetrates, the vapour diffuses to every part. Unfortunately, fumigation is only possible in an enclosed space, and is chiefly used in glass houses. It is possible to treat orchard trees by erecting an impervious cover over the trees, and this has been done in some centres, but it is much too expensive in labour to commend itself to most growers of fruit. The most effective gas for fumigation is hydrocyanic acid gas (familiar in solution as prussic acid). The vapour of nicotine may be used, but it is not so reliable, and considerably more expensive. Great care must be taken in using the gas, since it is exceedingly poisonous to human beings. It is also very liable to injure the plants themselves unless due precautions are taken. The chief of these are to avoid daylight during the treatment, and to see that the roots of the plants are comparatively dry before commencing—the "cyaniding" being done just previous to the periodical watering of the plants. One of the worst pests of plants under glass—the white fly—is only effectively controlled by fumigation. Generally two treatments are necessary, as the gas cannot be relied upon to kill the eggs

Method of "Cyaniding."

The gas is generated by the use of cyanide of potash or soda. The latter is preferable, being cheaper, and yielding a larger proportion of gas. The cyanide is used

at the rate of 1 oz. of sodium cyanide, which is placed in 1½ fluid oz. of sulphuric acid, diluted with 3 fluid oz. of water. For every 1000 cubic feet of space ¼ oz. of cyanide is sufficient, providing the house is closed up during the night. Every crevice and hole should be closed up, so as to make the house as air-tight as possible.

The acid mixture is placed in an earthenware jar, the correct amount of cyanide dropped in. The operator must then immediately leave the house to avoid inhaling any of the gas, which is rapidly evolved. The cyanide may be bought in safety zinc cartridges, which are slowly dissolved by the acid before the cyanide is attacked. If they are used, more acid must be employed, as some is used in destroying the zinc. Alternatively the cyanide may be dropped into the jar from the outside, by means of a string passing through a hole in the roof.

Tetrachlorethane.

Considerable success has attended the use of this volatile liquid in place of cyanide, and as it is only slightly poisonous, it is safer for amateur use. It appears to be slightly less effective than cyanide, and in some instances a certain amount of damage to the plants has apparently resulted from its use.[1] It is simply poured down the centre of the house in the evening. About ½ pint of the liquid for every 1000 cubic feet of space is necessary.

Tobacco and Nicotine Preparations.

These are used as "fumers," and are convenient for horticultural purposes, but generally too expensive for commercial use in the open. They are also far less effective on white fly than cyanide or tetrachlorethane, but are excellent for red spider and similar pests in greenhouses.

[1] This may have been due to the roots of the plants being too moist.

CHAPTER XV

PESTS OF THE APPLE TREE

INSECT PESTS

I. Sucking Insects

Blue Apple Aphis [1]—*Aphis malifoliæ.* (See Fig. 1, page 29.)

This is the worst of the aphis pests on apples. The colour varies from bluish to reddish or yellow. The shiny black eggs are laid on the buds and shoots in the autumn and hatch out in the early spring. The young lice gather on the buds, and later on feed upon the opening leaves, and cause them to curl very tightly. They disappear from the trees about the middle of July. (See diagram, page 41.)

Remedies.

1. Spray in autumn with soap and a contact insecticide,[2] or with a reliable proprietary soap wash to kill the egg-laying females, which are then on the surfaces of the uncurled leaves.

2. Spray *early* in spring (late dormant stage—see frontispiece), with washes as in 1, and later again if necessary.

Green Apple Aphis—*Aphis pomi.*

This pest is not so serious as the blue apple aphis. The lice are bright yellowish green with two dark spots on the head and black "horns" (cornicles). Leaves curl up soon after attack, and the aphis remains on the plant all the summer. Eggs, similar in appearance and location to the

[1] Also called "Purple aphis," "Rosy aphis."

[2] The most suitable insecticide for general use is some form of the active principle contained in Derris, which is very efficient and also non-poisonous. See pages 109, 110.

blue aphis, are laid in the early winter, which hatch out in the following spring.

Remedies.

As for blue apple aphis (see page 133).

Woolly Aphis—*Eriosoma lanigera* ("American Blight"). (See Figs. 57, 58, 59, pages 91-93.)

Woolly aphis is a serious pest on fruit trees almost wherever fruit is grown. The name is due to the white cottony material secreted by the aphis which entirely covers its body and hangs down from the infested trees. The aphis itself is a purple brown colour, and the "wool" adheres closely to the body. It is peculiar amongst aphides, attacking both the roots and branches of a tree, and is especially difficult to eradicate on this account. Eggs are not often produced, but living young are born all the year round, both above and below ground. Damage is caused by the loss of sap, and young trees are sometimes killed. The irritation caused by the punctures of the insect give rise to large swellings and deformities, and an attack of the canker fungus often follows.

Remedies.

1. Spray with a good "lathering" soap solution [1] and a contact insecticide (see Chapter XII.). A coarse, powerful spray should be used.

2. Paint the whole areas of infection with a brush dipped in methylated spirits (suitable for small trees in gardens).

3. Blow a good powder insecticide spray on to the attacked parts.

4. Simultaneously inject carbon bisulphide into the soil to kill the below-ground aphides (see page 93). This should be done before April, and in dry weather (see pages 60-62).

Apple Sucker—*Psylla mali*. (See Fig. 23, page 43.)

This is a serious pest on apple, especially in the Cambridge and Worcester fruit-growing districts. The eggs are oval, with a curled "tail," white when first laid, changing to a yellowish red, and are laid on the buds or twigs in autumn,

[1] See Chapter VIII.

hatching in the following spring. The date of hatching varies with the time of the opening of the buds. The young lice enter the buds, having flat, bristly bodies (see Fig. 2, p. 43). The winged insects appear in May.

The results of psylla attack are as follows :—

1. The blossom buds fail to open if many are present.

2. The blossoms open, but the petals rapidly shrivel, producing a brown truss, somewhat resembling weevil attack.

Remedies.

As for blue apple aphis.[1] The egg-laying suckers may be treated in autumn in the same manner. Spraying in spring *must* be done before the young suckers enter the buds (late dormant stage, see frontispiece). Benefit has been derived from a cover wash with lime (see page 114) in the spring.

Capsid Bug—*Plesiocoris rugicollis.* (See Fig. 23, page 43.)

The capsid bug originally fed upon the willows, and is often found upon other plants. It is a very serious pest in the Cambridge and Wisbech districts. The bug is much larger than an aphis, and very much more active, running over the leaves with great speed. The eggs are cylindrical in shape, and are embedded in the shoots, hatching out usually from the middle to the end of April, the young bugs entering the developing buds. They mature in May, and the eggs are laid during June and July. The damage is usually very serious. The insect punctures the leaves and shoots, which become stunted. More serious is the damage to the fruit, which is scarred and undersized, and usually quite unsaleable.

Remedies.

As for blue apple aphis (page 133). To destroy this pest a relatively strong and freely lathering soap solution is required. The amount to use depends upon the hardness of the water supply (see Chapter VIII.). Spraying should commence in the late dormant stage (see frontispiece). (See also pages 32 and 34.)

[1] See page 133.

Mussel Scale Insect—*Lepidosaphes ulmi.* (See Fig. 23, page 43.)

This very curious insect is very common, especially in old orchards. It forms scales not unlike minute mussel shells in appearance. If one of these be lifted with the point of a knife (they adhere very firmly) a mass of grey dust—the eggs—together with the shrivelled female insect will be found below. The eggs hatch out about June, and the small, very active mites crawl over the tree. They finally come to a standstill, and plunging their long beaks firmly into the bark of the tree commence to form a scale over the body. Eggs are laid under the scale and the female then dies. The male insect is rarely produced. Damage is caused by the exhaustion of the sap of the plant, and also by interference with the breathing-pores by the incrustation. Young trees finally succumb to the attack.

Remedies.

1. Spray in the winter with lime-sulphur 1·3 sp. gr. at winter strength, or with paraffin emulsion, with or without caustic soda.

2. Spray in the summer with any form of Derris [1] in conjunction with soap, or with a good proprietary fruit wash.

II. Chewing (Leaf-Eating) Insects

Winter Moth Caterpillar—*Cheimatobia brumata.*

This is probably the worst pest of fruit in this country. The caterpillar hatches out just before the bursting of the leaf buds in spring. It is smooth skinned, green, with pale lines along the body, and belongs to the "loopers" or "measurers," *i.e.*, it moves with a looping movement by placing the end of the body close up to the head, and then straightening out (as if measuring its own length). The caterpillars feed upon the young leaves, and may also attack the fruitlets. The damage is usually severe, and unless prompt measures are taken, trees may be entirely stripped of leaves.

The female moth is wingless, and emerges from the ground (where the chrysalis or pupa is found) between the end of

[1] See page 110.

September and the first week in January. It crawls up the trunks of the trees in order to lay the eggs on the branches, being fertilised by the male moth (which is

Fig. 81.—Tree with band of sticky composition to catch the wingless female of the winter and other moths.

winged) on its journey. Each female lays up to 300 eggs, which are greenish at first, and then become brick-red.

Remedies.

1. The trees should be banded with sticky composition

(*e.g.*, "Ostico") sold for this purpose. It is best to tie bands of grease-proof paper around the tree about 4–5 inches in width and overlapping slightly. They are then tied with two lengths of string above and below (see Fig. 81). The composition is then spread on the band with a stick or with the hand in a uniform, even coat, but not too thickly. A good composition should remain sticky till after the end of January, when all the females will have ascended the trunk.

2. Spray with Derris and soap (see page 115) or with arsenate of lead (see page 116), when the first signs of caterpillar are seen.

The Mottled Umber Moth (*Hybernia defoliaria*) is similar in habits and treatment is identical.

The March Moth Caterpillar (*Anisopteryx œscularia*) is similar in appearance, but more slender. The wingless female ascends the trees in March or up to April. It is advisable to keep the sticky bands in operation till the middle of April to catch this insect. Treatment as for winter moth.

Codling Moth Caterpillar — *Cydia pomonella* ("Apple maggot").

The damage done by this caterpillar is very familiar—it produces the so-called "maggoty apples" so common in our markets. The caterpillar is usually found inside the apple feeding near the core. Its life-history is as follows :— The egg—usually single—is flat and transparent, and is laid on the sides of the fruit or on the leaves. Many eggs are laid by each female on different apples. On hatching, the young caterpillar makes for the eye of the apple and there takes its first meal preparatory to entering the interior. It burrows its way to the core and there feeds till mature. A small hole is bored in the side of the apple, and here the brown excrement or "frass" appears.[1] The mature caterpillar finally makes its escape through this hole and shelters under the rough bark, or finds other protection on the ground. Here it spins a cocoon and passes

[1] See Fig. 9, page 30.

the winter. The moths emerge at the fall of the blossom and lay their eggs. There may be two or three broods in one season. The damage is often very serious, apples either falling from the trees or becoming unmarketable.

Remedies.

1. Spray with arsenate of lead (*immediately the blossom has fallen*—calyx stage, see frontispiece). A spot of arsenate is thus left in the eye of the fruit, and this is sufficient to poison the young caterpillar at its first meal. A fine misty spray is essential, and the time of spraying mentioned is vital to success (see Fig. 72). Further sprayings about three weeks and seven weeks later may be necessary if two or three broods appear.

2. Provide bands of sacking in the summer for the caterpillars to hide in, and remove and burn in the winter.

The Lackey Moth—*Clissiocampa neustria.*

The lackey moth caterpillar occurs as a destructive pest locally in certain seasons. It is the largest of the caterpillars occurring as a pest on fruit. The eggs are deposited by the female moths as a conspicuous band around the young branches, and remain through the winter. On hatching in the spring the young caterpillars enclose a few of the leaves in a fine web, and underneath these continue to feed. The nest is enlarged from time to time, and, after a final moult, they generally occupy a large "tent" in the bark of the tree.

Treatment.

Caterpillars, particularly when nearly full grown, may readily be destroyed by probing the nests with sacking tied at the end of long poles. The nests may also be cut out and burnt, or dispersed with a muzzle loading gun, charged with gunpowder and a paper wad.

The branches with egg bands should be removed where seen in the winter. Spraying is of little use, as it is difficult to penetrate the web, but Derris, with a strong solution of soft soap, has been found effective.

Tortrix and Bud Moth Caterpillars—*Tortrix varieties.*

The caterpillars appear in the summer and make winter hiding places under bits of bark and silk: at this stage they are quite minute, less than $\frac{1}{8}$th of an inch long. In the spring they enter the buds which they destroy; later they feed on the leaves, spinning them together. The moths appear in June and July.

Treatment.

1. Spray in late summer with arsenate of lead.
2. Spray when the buds are bursting with arsenate of lead, or better, with Derris and soap (see page 115).
3. Lime-sulphur used in the winter will kill many of the hibernating caterpillars.

Apple Blossom Weevil—*Anthonomus pomorum.* (See page 63, and Figs. 44, 45.)

Apple Sawfly—*Hoplocampa tertudinea.* (See page 67, Fig. 10, page 30, and page 34.)

FUNGUS DISEASES OF THE APPLE

Apple Scab (Black Spot)—*Venturia inequalis.*

This is by far the commonest and worst of fungus diseases attacking apples. Reference has been made to the disfigurement of the fruit on page 30 (see Figs. 14 and 15), also on page 104, Fig. 65. (See also page 32.)

Remedies. (See pages 33 and 105.)

Brown Rot—*Sclerotinia fructigeria.* (See pages 33 and 34, and Fig. 13, page 30, also Fig. 63, page 101, and page 107.)

Apple Mildew—*Podosphæra.* (See pages 106 and 107.)

Apple Canker—*Nectria ditissima.* (See Fig. 64, page 103, and page 106.)

Apple Blossom Wilt—*Monilia cinerea.* (See page 107.)

PESTS OF THE PLUM

INSECT PESTS

Leaf-curling Plum Aphis—*Aphis pruni.*

Like the blue apple aphis this pest curls the leaves very tightly, and renders it difficult to reach with a spray. The eggs (black in colour) hatch in the spring, and the lice, at first green, grow into large purple " queens," which produce living young at a great rate. The aphides leave the plum in June or July, and winged flies appear again in autumn, when egg-laying takes place. (See Fig. 27, page 46.)

REMEDIES.

As for blue apple aphis (see page 133).

Mealy Plum Aphis—*Hyalopterus pruni.*

Unlike all the aphides previously considered, this aphis appears in the summer about June or July, and great numbers of lice are produced on the leaves. They have a greyish, mealy appearance, and much sticky " honey dew " is secreted. The aphides fly off again in the autumn to an unknown plant. (See Figs. 25 and 26, pages 45 and 46.)

REMEDIES.

Spray in summer with soap and a contact insecticide, *e.g.* Derris in some form.[1]

Mussel Scale—*Lepidosaphes ulmi.* (See under apple, page 135.)

Winter Moth—*Cheimatobia brumata.* (See under apple, page 136.)

March Moth—*Anisopteryx æscularia.* (See under apple, page 138.)

Mottled Umber Moth—*Hybernia defoliaria.* (See under apple, page 138.)

Plum Fruit Sawfly—*Hoplocampa fulvicornis.*

The small pink maggot feeds inside the developing fruitlet in May and June, injuring and practically destroy-

[1] See pages 108 and 109.

ing same. When mature it enters the ground, spins a brown cocoon and winters thus, pupating in February. The sawfly, which has a black body with two pairs of transparent wings, appears in April and May.

Remedies.

1. Destroy all infested fruit.
2. Spray the blossoms with arsenate of lead (*q.v.*).

FUNGUS DISEASES

Plum Rot—*Sclerotinia fructigeria.*

This is the same disease which attacks apples, and treatment follows the same course (see page 140).

Silver Leaf—*Stereum purpureum.* (See description and treatment, page 108.)

The Plum Wither Tip—*Monilia cinerea* (Blossom Wilt).

The first sign of this disease is the wilting of the blossoms and the withering of the tips of the young twigs early in the season, causing them to curve over. Infection extends from the spores of the leaves to the shoots, causing the death of the tip. During the following winter fungus fruit is borne on the dead twigs, and also on mummified fruit remaining on the trees.

Treatment.

So far spraying appears of little use, but all withered tips and shoots and all fruit should be removed in the autumn.

PESTS OF THE PEAR

INSECTS

Black Aphis—*Aphis pyraria.*

The sooty black aphis often appears on pear leaves, causing them to curl up. As a rule the attack is not

serious, and can readily be controlled by spraying as for blue apple aphis (page 133).

Social Sawfly—*Pamphilus flaviventris.*

The maggots of this sawfly closely resemble caterpillars, living within webs similar to those of the lackey caterpillar. They devour the leaves inside the web, and in bad cases trees may be totally defoliated. The adult sawfly appears in May and June, and lays eggs under the leaves. When mature the sawfly maggots burrow into the ground and there pupate.

TREATMENT.

The best method of treatment where possible is the destruction of the tents by cutting out of the tree and placing in hot lime. An effective treatment is spraying the caterpillars with Derris [1] and soft soap, using a coarse powerful spray penetrating to the tents. Arsenate of lead is of little use unless applied before the larvæ have enclosed themselves within the webs.

Slug Worm—*Eriocampa limacina.*

This repulsive-looking maggot, which is slimy in appearance, resembling a small slug, attacks pear, cherry, and plum trees. It appears in early summer and produces blotchy spots on the upper surfaces of the leaves. The adult is a sawfly which is on the wing in early June.

TREATMENT.

The attacked trees may be sprayed with either arsenate of lead or with Derris and soft soap; the latter is preferable if the fruit is nearing maturity as it is non-poisonous.

Pear Midge—*Diplosis pyrivora.* (See Fig. 47, page 68.)

This is a common pest on pears and very destructive. The midge, which is a small two-winged fly belonging to the order *diptera*, appears in May, and the female lays her eggs inside the blossoms. The minute maggots which are

[1] See page 110.

produced infest the young fruitlets until they are mature in June, when they leave the decayed fruit and penetrate the soil to a depth of about two inches. Pupation takes place in the autumn or winter.

TREATMENT.

Spraying in the ordinary way is of little use, since the maggots are enclosed inside the fruitlets. Those which are attacked are readily seen on account of their swollen appearance, being circular in shape and much larger than the healthy ones. The infested fruitlets should be picked and burnt as soon as seen. Poultry in the orchards from June to August, and again in the spring, keeps the disease in check, and in bad cases it is advisable to kill the blossoms by means of a spray of Paris green and so starve the pest out. (See also pages 67-69.)

Pear Leaf Blister Mite.—*Eriophyes pyri.*

This insect is more common in America than in this country. Affected trees should be sprayed with lime-sulphur.

FUNGUS DISEASES OF THE PEAR

Pear Scab—*Venturia pyrina.*

This disease resembles apple scab very closely and the treatment is identical (see page 140).

Pear Leaf Spot—*Mycosphærella sentina.*

This disease occurs as small round spots on the upper surfaces of the pear leaves, later on the spots become greyish, surrounded with a brownish ring. The leaves may fall early in the season. No direct damage is done to the fruit, but the disease causes considerable weakening of the tree.

TREATMENT.

Spray with 1·3 sp. gr. lime-sulphur, 1 gallon to the 100 gallons of water—or rather more with hardier varieties—

immediately after the fall of the blossom, and give two further sprayings at intervals of three weeks.

PESTS OF THE PEACH

The peach is subject to one or two insect pests which attack other fruits, but they are not generally serious, and where they occur treatment follows the same lines.

FUNGUS DISEASES

Peach Leaf Curl—*Exoascus deformans.*

This is a very widespread disease on peaches. It causes distortion or crumpling of the leaves, which remain green at first, but later turn reddish-yellow, and finally a deep rosy red. At a later stage the spores of the fungus appear as a silvery bloom on the surface. The disease penetrates into the shoots and remains there throughout the winter, passing into the buds in the following spring.

TREATMENT.

All dead and diseased shoots should be cut away before the end of January, and a thorough spraying with Bordeaux or Burgundy mixture should be applied before the buds begin to swell (or say before the second week in March).

PESTS OF THE CHERRY

INSECTS

As for plum and peach.

FUNGUS DISEASES

Cherry Blossom Wilt and Canker—*Monilia cinerea.*

The disease is due to the same fungus which attacks the plum, see page 142.

Cherry Leaf Curl—*Exoascus minor.*

The disease causes the leaves of the cherry to become pinkish-red and curl up. Afterwards the leaves turn brown and drop from the trees.

Treatment.

Affected branches should be pruned off in winter, and the trees should be sprayed with Bordeaux mixture as the leaves are opening.

Cherry Leaf Scorch—*Gnomonia erythrostoma.*

This is a widespread disease, and causes the dead leaves to remain hanging on the branches throughout the winter. The disease produces discoloured patches on the leaves in early summer. The attacked portion spreads until the whole leaf presents a scorched appearance. Fruit is also attacked, causing it to fall or become distorted.

Treatment.

The withered leaves should be removed during the winter or early spring, this would prevent infection, but since neighbouring orchards may be left untreated, it is necessary to protect the leaves with a coating of Bordeaux mixture, applied once before the opening of the flower buds, and once again after their fall.

Cherry Scab—*Fusicladium cerasi.*

This disease occurs as greenish-black blotches on the ripe cherries, which later on become scabby in appearance.

Treatment.

Spraying with winter strength lime-sulphur just before the bursting of the buds, and with 1·3 sp. gr. lime-sulphur 1 gallon to the 100 gallons of water, if the disease appears on fruit.

PESTS OF CURRANT AND GOOSEBERRY

INSECTS

Gooseberry and Currant Sawfly—*Nematis ribesii.*

This is a common pest of gooseberries and currants, the maggots closely resembling caterpillars. They feed voraciously on the leaves of the plant from May onwards throughout the summer.

TREATMENT.

Spray thoroughly with soft soap and Derris (as described on page 115) as soon as the larvæ appear. Arsenate of lead is also effective, but must not be used within a month of the time of picking of the fruit.

Currant Clearwing—*Ægeria tipuliformis.*

This is a frequent pest especially in gardens. The clearwing caterpillar bores into the branch of the currant and causes a wilting of the shoots, or dwarfing of the leaves and fruit. Spraying is of no benefit, the only remedies being to prune off all the shoots below the holes, marking the spot where the caterpillar entered, and cutting back until all signs of tunnelling have disappeared.

Currant Gall Mite—*Eriophyes ribis* (Big Bud).

This is a very serious disease on currants, and widespread in England. The adult mite, which is very minute, is semi-transparent in appearance and of cylindrical form. The eggs occur as a whitish powder. The mites infest the buds of the currant, causing these to swell abnormally, and during April and May some of them burst, and the mites crawl over the plant. The disease also seems to produce a deformation of the leaves known as "nettle head" or "reversion."

Note.—Three species of aphis occur commonly on currants, which are best treated by spraying as for blue apple aphis (page 133).

TREATMENT.

The swollen buds should be picked by hand from the plants as soon as they appear. A winter spray, with 5 per cent. carbolic acid in a 10 per cent. solution of soft soap, is also advised to destroy the big buds which it penetrates. Benefit has also been derived by spraying with 1·3 sp. gr. lime-sulphur, 8 gallons to the 100 gallons of water, when the young leaves are about as large as a sixpenny piece.

Gooseberry Red Spider—*Bryobia pretiosa.*

This "insect" occurs as a destructive pest on gooseberries. The small spider or mite hatches out from the egg in early spring, and throughout the early summer eggs are laid which hatch in a few days, and soon grow to the adult form. The spiders suck the sap from the leaves, but do not produce a web, and are specially active in warm dry weather.

TREATMENT.

Spray with some form of Derris [1] and soft soap, with liver of sulphur, 4 lbs. to the 100 gallons, during February and early March, or with a good proprietary fruit wash.

FUNGUS DISEASES

American Mildew on Gooseberries—*Sphærotheca mors-uvæ.*

This is a serious disease of gooseberries, and it was specially prevalent a few years ago, when legislation was introduced for its control. It occurs as a delicate white film upon the young leaves and buds about May, which extends to the berries and shoots, and becomes greyish in colour owing to the formation of spores. At a later stage the fungus appears as brown felt on the berries and shoots.

TREATMENT.

Winter spraying is useless, owing to the very resistant spore cases of the fungus. Several sprayings may be given

[1] See page 110.

in the summer with lime-sulphur, 1·3 sp. gr., 1 gallon to the 100 gallons of water, or slightly stronger.

Die-back of Gooseberry—*Botrytis.*

This disease is becoming fairly common. It usually appears in single plants in a plantation, or may be confined to a small group of bushes. The stem is usually attacked near the surface of the soil and is gradually ringed by the fungus, becoming finally killed.

The fungal threads often travel up the stem and kill one of the branches. The leaves may be infected by spores and turn yellow at the edges or fall off the tree.

TREATMENT.

Remove and destroy dead bushes or branches. If the infection is severe, spray with 4 lbs. copper sulphate to 100 gallons of water just previous to the bursting of the buds, and again, when the fruit is set, with Bordeaux Mixture.

Currant Leaf Spot—*Pseudopeziza ribis.*

This disease appears as small black spots on the upper surfaces of the leaves, causing, in bad cases, an early leaf fall.

TREATMENT.

Spray as soon as the disease appears with 1·3 sp. gr. lime-sulphur, 1 gallon to the 100 gallons of water, or slightly stronger.

PESTS OF RASPBERRY, STRAWBERRY AND BLACKBERRY

INSECTS

The Raspberry Moth—*Tinea rubiella* (Red Raspberry Grub).

The moth produces caterpillars which infest the base of the buds of the raspberry, and then penetrate into the pith of the shoot, where they pupate, and the moths appear in

May or June, laying their eggs in the flowers. The young caterpillars winter in the soil.

TREATMENT.

The old canes should be cut close to the ground in the autumn and burnt. Spray with arsenate of lead in late March.

Raspberry Weevil — *Otiorhyncus picipes* (Clay-coloured Weevil).

This weevil, as its name implies, has a mottled clay-coloured appearance. It feeds at night and hides during the daytime, falling to the ground on being disturbed. It is extremely difficult to detect owing to its close resemblance to the soil. The young leaves and shoots, as well as the young fruit buds and blossoms, are attacked, and during the winter months the grubs attack the roots.

TREATMENT.

The weevil can be readily caught by providing a board smeared with banding composition (see page 137), and proceeding quietly through the plantations, holding the boards on each side of the canes, or under the plant, and then jarring the latter. The plants can also be well sprayed with arsenate of lead.

Raspberry Beetle—*Byturus tomentosus.*

This is a common pest on raspberries, the beetle devouring the blossoms or cutting them off. The grub infests the berries until mature. It is the common cause of "wormy raspberries," also of loganberries and blackberries.

TREATMENT.

Cut the canes well back in the autumn and burn the cuttings. Cultivate the ground in winter as much as possible, spray the young plants with arsenate of lead when the blossom buds appear, and also two weeks later.

Professor Lees has advised the following treatment :—

"Spray at three-weeks intervals in the following manner : First, with a 2 per cent. soft soap, plus 2 per cent. paraffin emulsion to bring the beetles out of hiding. Five minutes later, spray with the same emulsion after the addition of 8 oz. of pure nicotine per 100 gallons of solution."

Raspberry Aphis—*Amphonophora rubi.*

This is a fairly common pest on raspberries. The aphides feed on the undersides of the leaves, but do not curl them. It is not usually serious, and is easily controlled by the use of soap and a contact insecticide (*e.g.* Derris).[1]

Strawberry Aphis—*Myzus fragariella.*

This is not a common pest, but when it occurs it is treated in exactly the same manner as raspberry aphis (see above).

FUNGUS DISEASES OF RASPBERRY, STRAWBERRY AND BLACKBERRY

Raspberry Rust—*Phragmidium rubi-idei.*

This disease occurs as yellowish circular patches on the upper surfaces of the leaves in mid-summer. Another stage of the disease is similar in appearance to this with patches more of an orange tint, and a third form appears as black clusters on the under-surfaces of the leaves.

Treatment.

Control is somewhat difficult, but advantage is derived from summer spraying with 1·3 sp. gr. lime-sulphur, 1 gallon to the 100 gallons of water, or rather stronger.

Strawberry Leaf Spot—*Sphærella fragariæ.*

This disease occurs as small patches of red discolorations on the leaves, which increase in size and change to a

[1] See page 110.

grey tint. The fruit crop is badly affected, and the plant is greatly weakened in severe cases.

Treatment.

Lime-sulphur used at a strength of 1 gallon to the 100 gallons of water (or rather stronger, up to 1 gallon to 60 gallons), is the best spray, and has the advantage of also killing the strawberry mildew.

Strawberry Mildew—*Sphærotheca humuli.*

This fungus is the same species as that producing mouldy hops. The first symptom is the gradual turning upwards of the edges of the leaves, and if the under-surface of these is examined with a hand-glass, a delicate white down is seen spreading over the leaf. Before the mildew has time to spread to the berries, the plants should be thoroughly sprayed with lime-sulphur, 1·3 sp. gr., as described under strawberry leaf spot (see above).

INDEX

American Blight, *91*, *134*
„ Gooseberry Mildew, *149*, 107
Aphides, *44*, 32, 36
Aphis, Apple, *133*, 41, 36, 34
„ Mealy Plum, *141*, 45, 46
„ Pear, *142*
„ Plum Leaf-curling, *141*, 46
„ Raspberry, *151*
„ Strawberry, *151*
„ Woolly, *91*, 134
Apple Aphis, *133*, 41, 36, 34
„ Black Spot, *104*, 32, 140
„ Blossom Weevil, *63*, 140
„ Blossom Wilt, *107*, 140
„ Blue Aphis, *133*, 41, 36, 34
„ Brown Rot, *107*, 101, 33, 34
„ Canker, *106*, 107, 140
„ Capsid, *135*, 32, 34, 43
„ Diseases of, *133*
„ Green Aphis, *133*, 41, 36, 34
„ Mildew, *106*, 107, 140
„ Sawfly, *67*, 30, 34
„ Scab, *104*, 32, 140
„ Sucker, *134*, 43.
Appliances, Spraying, *125–129*
Application of Spray, *120*
Arsenate of Calcium, *116*, 54
„ of Lead, *116*, *54–61*, 124, 128
Automatic Sprayers, *127*
Autumn Spraying of Fruit, *38*

Banding Composition, *137*, 65
Barrow Sprayers, *126*
Big Bud of Currant, *147*
Bisulphide of Carbon, *92*
Black Spot of Apple, *104*, 32, 140
Blue Apple Aphis, *133*, 41, 36, 34
Bluestone (Copper Sulphate), *118*
Bordeaux Injury, *128*
„ Mixture, *118*
Brown Rot, *140*, 142, 30, 101, 107, 33, 34
Bryobia, *148*
Bud Moth, *139*
Bug, Capsid, *135*, 32, 34, 43
Burgundy Mixture, *119*

Calcium Arsenate, *116*, 54
„ Caseinate, *117*
Canker of Apple, *106*, 107, 140
"Capped" Blossoms, *63*
Casein, *117*
Caseinate of Lime, *117*
Caterpillar, Bud Moth, *139*
„ Codling Moth, *138*, 30
„ Lackey Moth, *139*
„ March Moth, *138*
„ Mottled Umber Moth, *138*
„ Tortrix Moth, *139*
„ Winter Moth, *136*
Caustic Alkali, *114*, 83
„ Potash, *84*
„ Soda, *114*, 83
Cherry, Diseases of, *145*
Classification of Insects, Practical, *42*
Codling Moth, *138*, 30
Combined Sprays, *128*
Contact Poisons, *109*, 44
Currant, Diseases of, *147*
„ Gall Mite, *147*
„ Lettuce Aphis, *147*
„ Reversion of, *147*
„ Sawfly, *147*

Derris, *109*, *110*, *115*, 44, 53, 87, 95
Derrisine, *110*, 116
Dry Spraying, *129*, 45
Dusting Apparatus, *129*

Eelworm, *90*
Emulsions, *113*

Fatty Acids, *85*
Fumigants, *132*
Fumigation, *131*, 45
Fungicides, *102*, *118*
Fungus Diseases, *99*
„ American Gooseberry Mildew, *149*, 107
„ Black Spot, *104* ,32, 140
„ Apple Blossom Wilt, *107*, 140
„ Apple Brown Rot, *107*, 101, 33, 34
„ Apple Canker, *106*, 107, 140
„ Apple Mildew, *106*, 107, 140
„ Apple Scab, *104*, 32, 140
„ Cherry Blossom Wilt, *145*
„ Cherry Leaf Curl, *146*
„ Cherry Leaf Scorch, *146*
„ Cherry Scab, *146*
„ Currant Leaf Spot, *149*

Fungus, Gooseberry Die-back, *149*
,, Peach Leaf Curl, *145*
,, Pear Leaf Spot, *144*
,, Pear Scab, *144*
,, Plum Rot, *142*
,, Plum Silver Leaf, *142*, *108*
,, Plum Wither Tip, *142*
,, Raspberry Rust, *151*
,, Strawberry Leaf Spot, *151*
,, Strawberry Mildew, *152*

Gall-nut Meal, *66*
Gas, Hydrocyanic Acid, *131*
,, Lime, *96*
Gooseberry, American Mildew, *149*, 107
,, and Currant Sawfly, *147*
,, Die-back, *149*
,, Red Spider, *148*
Grease Banding, *137*, 65

Hardness of Water, Chapter VIII.
Hopper, Leaf, *43*
Hydrocyanic Acid Gas, *131*

Infection, by Fungi, *100*
Injury, by Hail and other Physical Causes, *28*
Insecticides, *109–117*

Kainit, *96*
Katakilla, *110*, *115*

Lackey Moth, *139*
Lead Arsenate, *116*, *54–61*, 124, 128
Lime, *114*, 66
Lime-Sulphur, *113*, 87, 102, 66
London Purple, *53*

Machinery, Spraying, *125–128*
March Moth, *138*
Mealy Plum Aphis, *141*, 45, 56
Medium Power Sprayer, *127*
Methods of Spraying, *120–130*
Mildew, American Gooseberry, *149*, 107
,, Apple, *106*, 107, 140
,, Strawberry, *152*
Mussel Scale, *135*, 43

Nettle Head of Currant, *147*
Nicotine, *111*, 87, 45
Nozzles for Spraying, *123*

Paraffin, *113*
,, Emulsion, *113*
Paris Green, *53*
Peach Diseases, *145*
,, Leaf Curl, *145*
Pear Aphis, *142*
,, Diseases, *144*
,, Leaf Spot, *144*
,, Midge, *143*, 67–69
,, Scab, *144*
,, Social Sawfly, *143*
Phylloxera, *97*
Plum Diseases, *142*
,, Fruit Sawfly, *141*
,, Leaf Curling Aphis, *141*, 46
,, Mealy Aphis, *141*, 45, 46
,, Rot, *142*
,, Silver Leaf, *108*, 142
,, Wither Tip, *142*
Polvo, *110*, *115*
Potassium Cyanide, *131*
Powder Spraying, *129*
Power Sprayers, *129*
Psylla, Apple, *134*, 43
Pyrethrum, *117*

Quassia, *112*

Raspberry Aphis, *151*
,, Beetle, *150*
,, Moth, *149*
,, Rust, *151*
,, Weevil, *150*
Red Spider, *148*
Reversion of Black Currant, *147*

Sawfly, Apple, *67*, 30, 34
,, Gooseberry and Currant, *147*
,, Pear, Social, *143*
,, Plum Fruit, *141*
Scale, Mussel, *135*, 43
Silver Leaf Disease, *108*, 142
Slugworm, *143*
Soap, Soft, *117*, 84–85, 47, 78, 50
Social Pear Sawfly, *143*
Soda, Caustic, *114*, 83
,, Cyanide, *131*
Soft Soap, *see* Soap, Soft
Soil, Insects, Chapter X.
Soot, *96*
Spiders, Red, *see* Red Spider
Sprayers, Chapter XIII.
Spreaders, *47*, 117
Strawberry, Diseases of, *151*
Sucker, Apple, *134*, 43

Water, Hardness of, *71*
,, Testing, Chapter VIII.
,, Varieties of, *72–73*
Weevil, Apple Blossom, *63*, 140
,, Raspberry, *150*
Winter Moth, *136*
Wither Tip of Plum, *142*
Woolly Aphis, *91*, 134

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